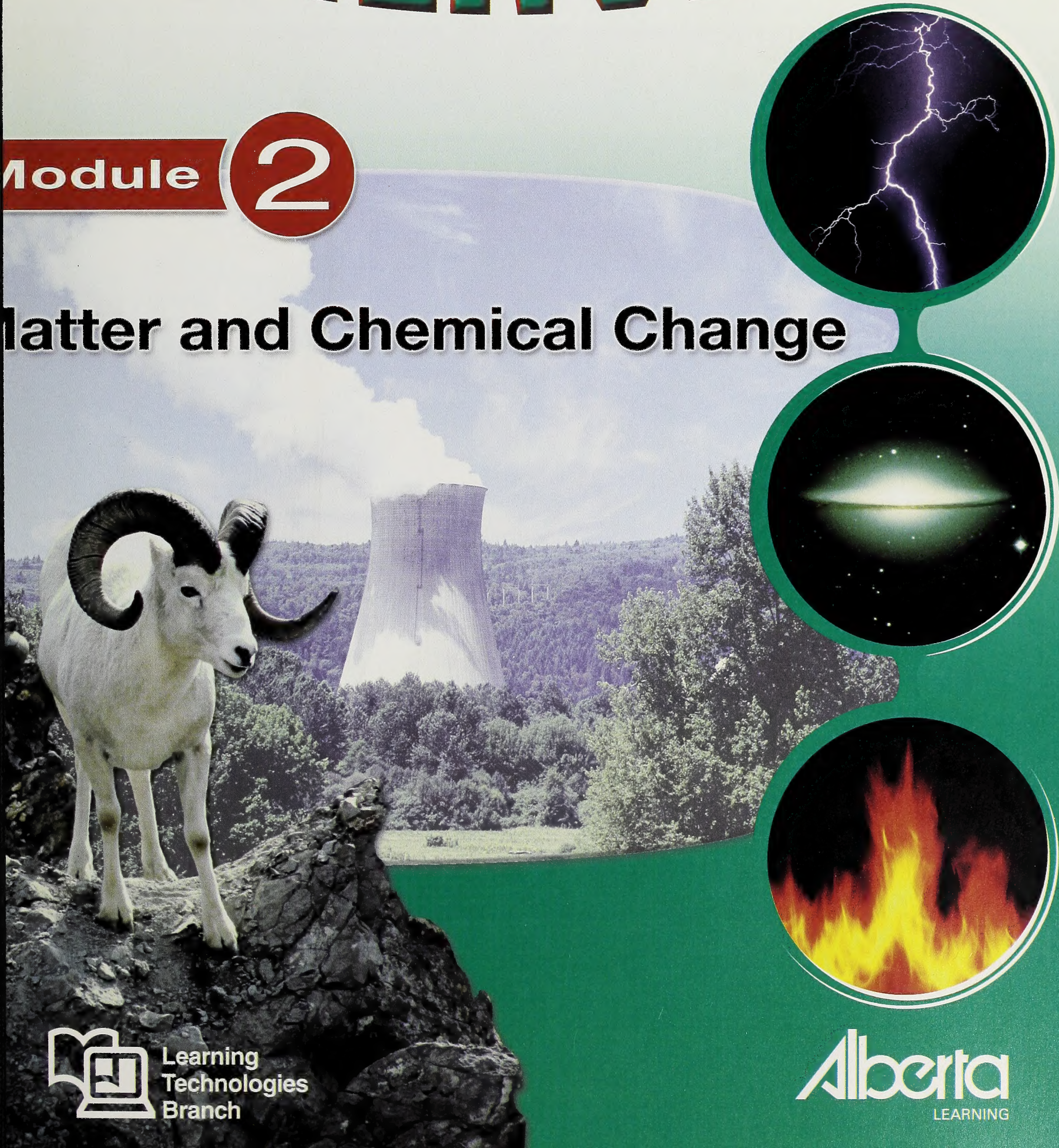
SCIENCE 9

Module 2

Matter and Chemical Change



Learning Technologies Branch

Alberta LEARNING

SCIENCE 9

Module 2 Matter and Chemical Change

Science 9
Module 2: Matter and Chemical Change
Student Module Booklet
Learning Technologies Branch
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The Learning Technologies Branch acknowledges with appreciation the Alberta Distance Learning Centre and Pembina Hills Regional Division No. 7 for their review of this Student Module Booklet.

This document is intended for	
Students	✓
Teachers	✓
Administrators	
Home Instructors	
General Public	
Other	

You may find the following Internet sites useful:

- Alberta Learning, **http://www.learning.gov.ab.ca**
- Learning Technologies Branch, **http://www.learning.gov.ab.ca/ltb**
- Learning Resources Centre, **http://www.lrc.learning.gov.ab.ca**

The use of the Internet is optional. Exploring the electronic information superhighway can be educational and entertaining. However, be aware that these computer networks are not censored. Students may unintentionally or purposely find articles on the Internet that may be offensive or inappropriate. As well, the sources of information are not always cited and the content may not be accurate. Therefore, students may wish to confirm facts with a second source.

WELCOME to Science 9!

It is recommended that you work through the modules in order because the concepts and skills introduced in one module will be reinforced, extended, and applied in later modules.

Module 1 Biological Diversity

Module 2 Matter and Chemical Change

Module 3 Environmental Chemistry

Module 4 Electrical Principles and Technologies

Module 5 Space Exploration

Module 1 contains general information about the course components, additional resources, icons, assessment, and strategies for completing your work. If you do not have access to Module 1, contact your teacher to obtain this important information.

Contents

Resources

Textbook

To complete the course, you need the textbook *ScienceFocus 9*.

Multimedia

Attached to Student Module Booklets in this course are CDs titled *Science 9 Multimedia* and *Science 9 Multimedia*: *Astronomy*. These CDs contain multimedia segments designed to help you better understand particular concepts presented in this course. Ask your teacher or home instructor if you need help using these CDs.

Materials and Apparatus

A list of materials and apparatus is given on the Planning Ahead page of each Student Module Booklet. These items are needed to complete the module. Some of the materials and apparatus may be provided at your local school lab. If you don't have access to a school lab, you will need to get the loan kit. Talk to your teacher for more information.

Before You Begin

Organize your materials and work area before you begin: Student Module Booklet, textbook, notebook, pens, pencils, and so on. Make sure you have a quiet area in which to work, away from distractions.

Because response lines are not provided in the Student Module Booklet, you'll need a looseleaf binder or notebook to respond to questions and complete charts. It's important to keep your lined paper handy as you work through the material and to keep your responses together in a notebook or binder for review purposes later.

Refer to the Planning Ahead page for directions on what you need to do before you start this module.

Good luck!

Icons

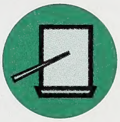
This is one of five Student Module Booklets for Science 9. As you progress through this module, you will meet several icons.

Do Ahead

Some preparation must be started well ahead of the activity or investigation. E.g., start the seedlings for the investigation in Lesson 3.

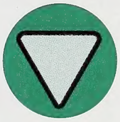
Teacher or Home Instructor

The teacher or home instructor should be contacted for help, approval of some procedure, or checking answers.



Assignment Booklet

Work needs to be done in an Assignment Booklet.



Safety

You must be very careful when you see this symbol.

Textbook

A reference is made to *ScienceFocus 9*, the student textbook for this distance learning course.

Internet

This is a reference to the Internet. **Note:** Any Internet website given is subject to change.

Multimedia

This is a reference to the *Science 9 Multimedia* CDs.

Computer

You will need to work with a computer when you see this symbol.

Module Overview

Canada Day is on July 1st every year. On that day, Canadians celebrate the anniversary of the formation of their nation. There are many local celebrations across Canada. In many centres the highlight of the celebrations is the fireworks display just after sunset.

Section 1
The Building Blocks of Matter

Section 2
The Chemical Nature of Matter

Section 3
Characteristics of Chemical Reactions

Fireworks are created due to exploding shells launched from the ground. The brilliant light and the colours of the display depend on the substances the manufacturer has put inside the shell. The manufacturer has to know about the properties of these substances and how they will interact. Such knowledge is based on ideas about the chemical nature of substances.

In this module you will investigate materials and describe them in terms of their properties. You will identify and interpret patterns in the reactions between substances. And you will use a system of naming to refer to substances and to describe reactions between them.

Check out pages 88 to 91 of the textbook to see what's ahead in this module.

Assessment

The booklet you are presently reading is the Student Module Booklet. It will show you, step by step, how to advance through Module 2: Matter and Chemical Change.

This module, Matter and Chemical Change, has three sections. Within each section your work is grouped into lessons. Within the lessons there are readings, investigations, activities, and questions for you to do. By completing these lessons you will discover scientific concepts and skills, develop a positive attitude toward science, and practise or apply what you have learned.

Suggested answers in the Appendix of this Student Module Booklet will provide you with immediate feedback on the answers to questions in the lesson. Your teacher or home instructor will also provide you with feedback on your progress through the module.

At several points in this module you will be directed to an accompanying Assignment Booklet. Your grading in this module is based on the assignments you submit for assessment. In this module you are expected to complete three section assignments and a Final Module Assignment.

The mark distribution is as follows:

Assignment Booklet 2A	
Section 1 Assignment	41 marks
Section 2 Assignment	37 marks
Assignment Booklet 2B	
Section 3 Assignment	22 marks
Final Module Assignment	50 marks
TOTAL	150 marks

Planning Ahead

Here is a list of materials and apparatus you will need to complete this module.

Section 1

- ❏ No extra materials are needed for this section.

Section 2

- ❏ marshmallows
- ❏ toothpicks

Section 3

- ❏ a candle
- ❏ a candleholder
- ❏ matches
- ❏ frozen, flavoured water
- ❏ a 250-mL measuring cup
- ❏ sugar
- ❏ a 5-mL spoon or a teaspoon
- ❏ a stirring rod or a spoon
- ❏ a commercial antacid tablet
- ❏ a small, self-sealing plastic bag
- ❏ a drinking glass
- ❏ a metal cooking pot
- ❏ a cooking stove or a hot plate

If you have access to the Internet, you may want to check out some of the links for this module ahead of time. Go to the following sites:

http://www.mcgrawhill.ca/school/booksites/sciencefocus+9/student+resources/toc/index.php

http://www.webelements.com/news

Section 1

The Building Blocks of Matter

Have you ever watched a bricklayer at work? A structure rises brick by brick. Visible parts are bonded together by mortar and are joined to make a whole structure. The structure the bricklayer builds is made up of smaller parts.

Even matter that seems to be of uniform composition is made up of smaller parts—or particles. These particles are both invisible and extremely small. These tiny particles are the focus of this section.

In this section you will build on your background knowledge about the makeup of substances by doing some hands-on investigations. When exploring substances you will be re-acquainted with safety procedures. You will also be introduced to scientific models and theories about the nature of matter.

Lesson 1: Exploring Matter

Have you ever done some hiking to explore a new region? Maybe you did your exploration in the mountains. Then you know the excitement of finding out more about a remote area that you're curious about. If you did some mountaineering you know that safety is important.

There is also much to explore about matter itself. Matter is not something remote—it's all around you. Matter is what you eat, breathe, wear, and interact with on a daily basis. Air and water... gas and liquid... these are common forms of matter.

To explore matter you don't have to be anywhere far away and you don't need really fancy equipment. Read the first two paragraphs on page 92 of your textbook.

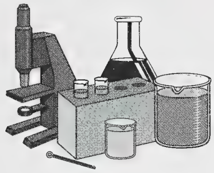
Putting Safety First

Kabooooom! You don't want something like this to happen near you! Improperly controlled reactions can be dangerous. Using proper safety equipment and procedures can prevent harm and keep the fun in science!

Read "Safety in Your Science Classroom" on pages xxvi to xxviii of the textbook. The rules apply not only in classrooms but to any place—such as a room in your home—where you do science investigations.

1. Match the safety rules on the right side of the graphic to the appropriate memory cues on the left. Write your answers in your notebook.

______ a.



______ b.

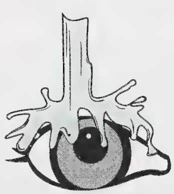
______ c.

______ d.

______ e.

______ f.

______ g.



A. Carefully listen to or read any instructions given to you by your home instructor or noted in your Student Module Booklet.

B. Clean equipment after use. Do not use cracked or broken containers.

C. Immediately flush chemicals from your eyes with water for 15 minutes.

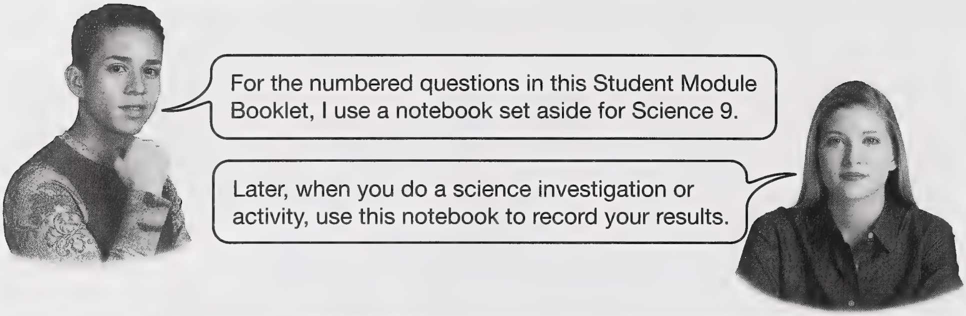
D. Never smell fumes directly—waft them toward you.

E. Obtain the approval of your home instructor before beginning an activity.

F. Point containers being heated away from yourself and others. Be aware of those around you.

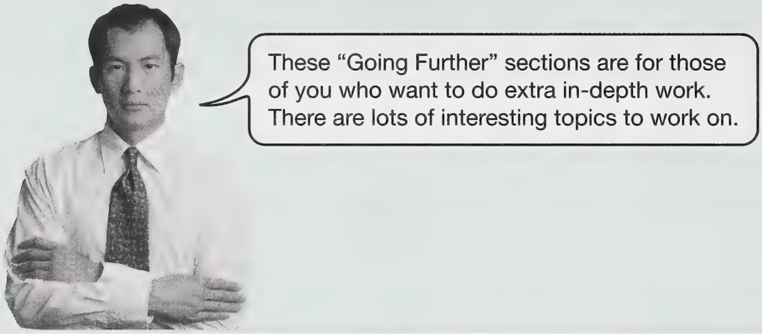
G. Wash after activities. Wash off potentially dangerous substances immediately and thoroughly.

Compare your responses with those in the Appendix on page 74.



Going Further

"Tough as Nails," the final project for this module, is introduced in "Looking Ahead" on page 91 of the textbook. This project is about factors affecting the chemical changes that occur during the process of corrosion. Read "Looking Ahead" to prepare for your own investigation.



Read "Safety First" on pages 92 and 93 of the textbook. Also read "Did You Know?" on page 93.

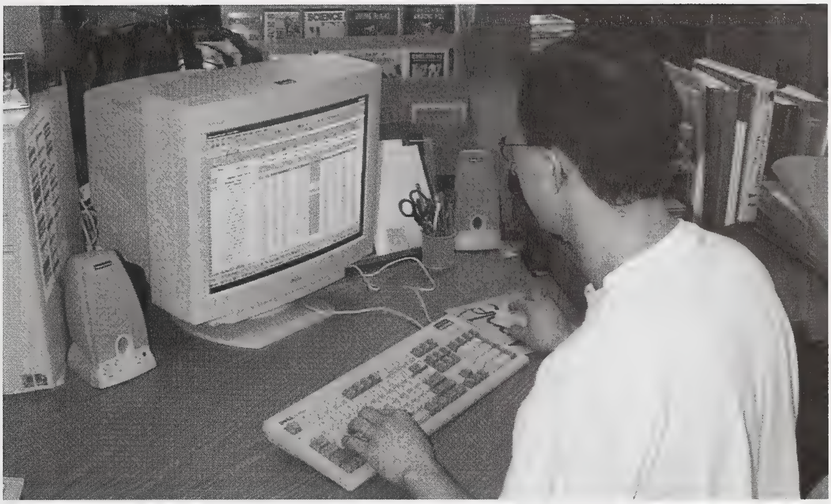
2. How long does it take for some mercury compounds to start being absorbed through the skin?

3. Some materials are poisonous. How are caustic materials dangerous?

Have you noticed hazardous product symbols on poisons in your home? Such poisons may be labelled with an icon containing a skull and crossbones. Review a few safety symbols and learn a few more symbols in the next "Going Further" activity.

Going Further

Workplace Hazardous Materials Information System (WHMIS) symbols are used around the world to alert people to the possible dangers of chemicals and equipment. Find out more about them. Try the "Computer Connect" on page 94 of the textbook. You may want to use the downloaded symbols you find in the next activity.



Imagine using a new computer without reading the documentation that comes with it. Because of this, you may never make full use of the computer features. To get full protection from safety symbols, you need to need to know what they mean. The safety symbols become meaningful when you read their descriptions.

Find Out Activity Put Safety First

Refer to the activity on page 93 of the textbook.

Do steps 1 to 3 of "Procedure" but don't fill in the "Example" column in the table.

Ask your friends, family, or home instructor to help you with step 4 of "Procedure."

4. Do "What Did You Find Out?" questions 1 to 3.

Compare your responses with those in the Appendix on page 74.

You're on a plane and ready to fly to an exotic destination. First, you're told how to fasten your seat belt. Then the flight attendant provides you with the information you need for an emergency. You are told where the exits are, where the oxygen masks come from, and where the flotation devices are. It's good to be prepared—even when you expect things to go well.

It's also important to be prepared for the unexpected when you do scientific investigations. That's what the next "Going Further" is about.

Going Further

Do the “Find Out Activity: Fasten Your Safety Seat Belt,” on page 94 of the textbook. You will increase your awareness of safety equipment. You may need permission to visit a teacher-supervised school laboratory. Check with your home instructor or teacher for permission.

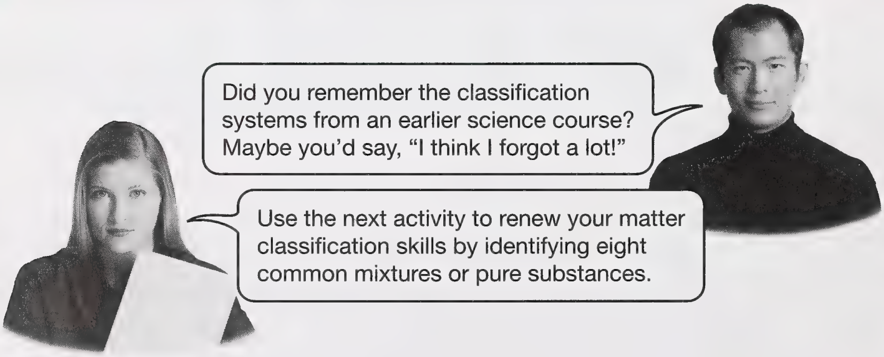
Classification of Matter

Have you ever used advertisements in a newspaper or a phone book to find a pet, sports equipment, or tickets? Check them out if you haven’t. Notice that similar items have been sorted into labelled groups. This classification system increases the speed of communication and identification—your search is much more efficient. Classifying matter based on physical and chemical properties helps make sense of a variety of materials.

Review the particle model and two classification systems by reading page 95 and the top of page 96 in the textbook.

5. Identify two systems that can be used to classify matter.

Compare your response with the one in the Appendix on page 74.



Find Out Activity A Classification Puzzle

Refer to the activity on page 96 of the textbook. Instead of unidentified samples you will classify substances described in the table.

6. Copy and complete the following table. You may obtain or prepare the substances listed. Looking at the actual substances may help you.

There is a reference list of some pure substances and their properties on pages 442 to 445 of the textbook.

Classifying Matter Based on Composition

Sample Number	Substance(s)	Number of Visible Components	Classification
1	"gold" jewellery		
2	salt		
3	water		
4	oil and water		
5	aluminum foil confetti and coarsely crushed chalk		
6	food colouring		
7	steeped tea without the leaves		
8	a mixture of coarse spices, e.g., oregano, parsley, dried onion		

7. Answer questions 1 to 3 from "What Did You Find Out?" and "Extension" on page 96.

Compare your responses with those in the Appendix on page 74.

Do you like salad dressing? It often contains ingredients dissolved in oil and other ingredients dissolved in water. Imaging letting a mixture of oil and water stand for awhile. It would soon separate.

An ingredient used to bind oil and water—called an emulsifying agent—can be added to prevent the separation of the dressing.

The following "Going Further" allows you to explore emulsifying agents.

Going Further

"Find Out Activity: Keep It Together" on page 98 of the textbook gets you shaking. It's also a lot of fun!

Just be very sure that your container of choice has a tight, secure lid!

8. Turn to page 98 of your textbook and answer questions 4 and 5 of "Topic 1 Review."

Compare your responses with those in the Appendix on page 76.

Looking Back

In this lesson you followed safety procedures as you investigated substances. You used the particle model of matter to make sense of observations. You classified matter by their states—solid, liquid, or gas. You also classified substances as

- mixtures or pure substances
- heterogeneous mixtures or homogeneous mixtures
- mechanical mixtures, suspensions, or colloids

Turn to Assignment Booklet 2A. Complete questions 1 to 3 from Section 1.

Lesson 2: Changes in Matter

property: *a characteristic of a substance that helps describe it*

physical change: *a change in form but not in chemical composition*

In a physical change, no new substances are formed.

chemical change: *a change in which one or more new chemical substances are formed*

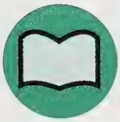
Imagine grocery shopping in a store where the tin cans are all unlabelled. Then you wouldn't know whether you were buying tinned fruit or tinned vegetables. You might come home with dog food or pizza sauce. Most of the **properties** of the substance inside the tin would remain unknown until you opened the container. Then it would be too late.

Properties of substances are important when you're shopping. They are also important when you're studying matter. Properties allow substances to be identified. Also, a change in a property (or properties) of a substance can be an important signal. It can indicate that a substance has experienced a **physical change** or a **chemical change**.

Dry ice is carbon dioxide in a solid form. The temperature of dry ice is – 78.5° C or colder! Left at room temperature, dry ice undergoes a curious physical change—it passes directly from a solid state to a vapour state. You can observe this change by going to the *Science 9 Multimedia* CD.

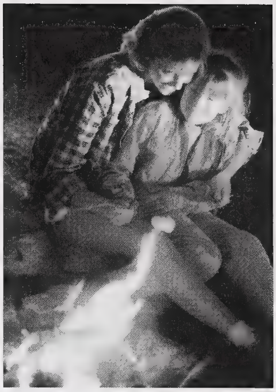
Science 9 Multimedia is provided to you with this course. Play this CD on a computer. Once the menu screen appears, select the title "Chemical Glossary." Then you can choose from a selection of terms. At this time, select "Carbon Dioxide."

As you continue with this module, return to "Chemical Glossary" for illustrations and definitions for other chemicals and specialized terms.



Turn to page 99 of the textbook and find out more about physical change and chemical change.

Think of a campfire. It's an example of a common chemical change. As with all chemical changes, you start with one or more substances and end with a different substance or substances. Energy is lost or gained in the process.



Has it occurred to you that the toasting of a marshmallow is a chemical change? It is. On the other hand, the changes that occur when the campfire logs are chopped and arranged are just physical changes.

1. Classify the following changes as physical or chemical.

   a. Leaves turn from green to yellow and then to red.

   b. Leaves are raked into a pile.

   c. Dry leaves break into smaller pieces.

   d. Photosynthesis takes place in leaves.

   e. Cellular respiration takes place in leaves.

   f. Leaves burn.

   g. Matter changes size, shape, or location, or it dissolves. In the process of change, energy may be converted from one form to another. The change starts with one form of matter and ends with the same form of matter.

   h. A change starts with one form of matter and ends with another form of matter.

Compare your responses with those in the Appendix on page 76.

In the next investigation you will study two reactions.

- The first reaction produces the mineral calcium carbonate and common salt. Geologists use the term *calcite* to describe calcium carbonate.

- The second reaction is an acid test. The acid test is used to identify limestone and dolomite, which are types of carbonate rock.

If you have access to a teacher-supervised laboratory, follow “Procedure” in Investigation 2A from the textbook.

If you do not have access to a supervised laboratory, use the “Observing Changes” table given to you in the investigation that follows.

Investigation 2A Physical and Chemical Changes in Ancient Alberta

Refer to the “Inquiry Investigation” on pages 100 and 101 of the textbook. Read through the entire investigation.

Look at the list of materials. Both sodium carbonate and calcium chloride are naturally occurring. They are also found in many households. Sodium carbonate is found as washing soda, while calcium chloride is used in sidewalk deicer. Small amounts of calcium chloride are found in some foods as preservatives.

You may refer to the following table for the results of each procedure.

Observing Changes

Procedure Summary	Observations
Part 1: Dissolved sodium carbonate and dissolved calcium chloride (both found in seawater) are combined.	A white solid forms and settles out of the clear mixture (calcium carbonate—the mineral calcite which forms limestone rock).
Part 2: The mixture produced in Part 1 is filtered. Hydrochloric acid is dropped on the residue.	The calcite (residue) is trapped in the filter, and the liquid (filtrate) is collected below. Bubbles are produced. The calcite disappears.
Part 3: Water is evaporated from the filtrate.	Tiny whitish crystals are left behind.

2. Look closely at the chemical names of the substances in the following statement:

   Calcium chloride and sodium *carbonate* combine to form calcium carbonate.

   a. What two “names” are left over in the substance you start with?

b. What common substance may have formed from these leftover parts? Where did this substance "go"?

c. The statement describes what chemists call an "exchange reaction" or a "replacement reaction." Why do you think these expressions are appropriate?

3. Answer questions 4 to 6 of "Conclude and Apply" and questions 7 and 8 from "Extend Your Knowledge."

Compare your responses with those in the Appendix on page 77.

end of investigation

Clues to Chemical Changes

Watermelon is very refreshing to eat on a hot summer's day. Imagine dropping one on the way to the picnic table. The watermelon may end up looking like the one shown in the textbook reading on page 102.

The change to the watermelon looks drastic, but is the change just physical? Or is it also chemical? It's not so important to classify the change to the watermelon—it's almost a lost cause. But in a systematic study of matter and its changes, such a classification is important.

The following reading will give you a simple guide to help you classify changes.

Read "Can You Ever Be Sure About Changes?" on page 102 of the textbook.

4. Which of the following clues definitely shows that a chemical change (a chemical reaction) has taken place?

   a. Energy (e.g., electrical, thermal, light) is absorbed or emitted.
   b. A new substance is formed.
   c. There's a change in colour or odour.
   d. There are bubbles or a solid form in a liquid.
   e. It's difficult to reverse.

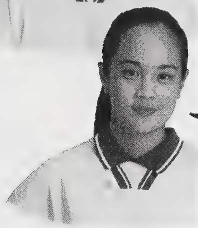
5. Answer the textbook question under "Figure 2.9."

Compare your responses with those in the Appendix on page 77.

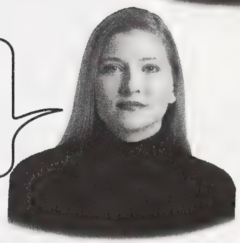
Physical and Chemical Properties

There's nothing like a hot air balloon ride for excitement. And it's a great way to look at the scenery.

Did you know that a physical property of hot air inside the balloon is responsible for lifting you high up into the air?



I know that the hot air is less dense.



Yes, density is the physical property of the hot air that's so important for a balloonist. The chemical property of the fuel—that it will burn—is important to producing the hot air.

Read pages 103 to 105 of the textbook to find out about physical properties and chemical properties.

6. Define *chemical property* and *physical property*.

7. **a.** Answer the question under "Figure 2.10."
b. Answer "Figure 2.11" questions. Classify properties as chemical or physical.

Compare your responses with those in the Appendix on page 78.

8. Turn to textbook page 105 and answer questions 2 and 5 of "Topic 2 Review."

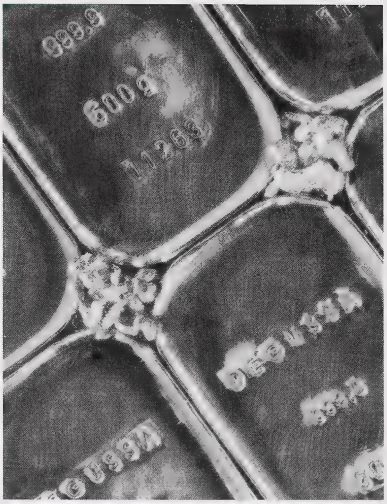
Compare your responses with those in the Appendix on page 78.

Looking Back

In this lesson you investigated physical and chemical changes. You also distinguished between physical and chemical properties.

Turn to Assignment Booklet 2A. Complete questions 4 and 5 from Section 1.

Lesson 3: What Are Elements?



Have you ever seen or held an ingot of pure gold? Or maybe a $100 gold coin from the Royal Canadian mint? If so, you've been exposed to a much-prized element.

In the Middle Ages, alchemists practised a type of chemical "science." Their aim was to find a way to convert common metals—such as copper, tin, or zinc—into gold. In their search for a method to make gold, alchemists stumbled on properties of many materials. They also developed some techniques that were later useful in laboratories. For its knowledge of materials and practical techniques, alchemy can be thought of as the forerunner of real chemistry.

Alchemy was little more than an imaginary art. Besides looking for a "magical" way to make gold, alchemists searched for a cure-all for diseases—a panacea. They also looked for a substance to promote longevity. However, in alchemy, there was not enough emphasis on experimentation and observation for progress to be made.

Brick by brick by individual brick—a wall, a frame, or a building appears where once there was only a vacant lot. The development of scientific knowledge is a similar process. Scientific laws and theories serve as a foundation for new laws and theories.

Read pages 106 and 107 of the textbook. You'll read about the beginnings of chemistry as a science.

Think of a campfire. When wood burns oxygen from the air, the chemicals that form the wood react to produce gaseous water, carbon dioxide, and other substances. Heat and light energy are released during the reaction.

Think about comparing

- the mass of the wood and oxygen consumed in the reaction
- the mass of gaseous water, carbon dioxide, and other products of the fire

1. According to Antoine Lavoisier, how do the masses compare? Write your answer in your notebook.

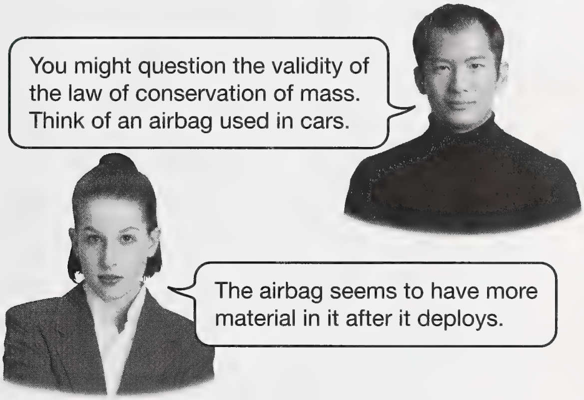
2. Copy the following into your notebook. Fill in each blank with the word *compound* or *element*.

    A(n) ____________ is a pure substance made up of one or more chemically combined ____________. A(n) ____________ is a pure substance that cannot be broken down into simpler substances through chemical change.

Substances that aren't pure have properties that can vary. For example, soft drinks can go flat when the carbon dioxide escapes. The taste of hot chocolate can vary—depending on who makes it.

3. How are the properties and composition of pure substances—whether they are elements or compounds—different from impure substances?

Compare your responses with those in the Appendix on page 79.

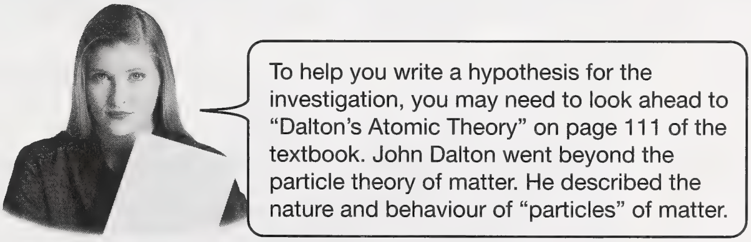


The next investigation gives you the opportunity to validate the law of conservation of mass.

inference: a conclusion or decision made by reasoning

observation: the use of senses to gather information

It's also the actual information obtained through the process of observation.



You will be asked to draw **inferences** from observations. An **observation** is information measured or directly noticed with your senses.

If you have access to a teacher-supervised laboratory, carry out the steps of "Procedure" from the textbook.

If you do not have access to a supervised laboratory, use the "Observing a Chemical Change" table given to you in the following investigation.

Investigation 2B Mass and Chemical Change

Read the "Inquiry Investigation" on pages 108 and 109 of the textbook.

4. Write a hypothesis about the relationship between the mass of the reactants and the mass of the products.

Use the representative data to answer the questions that follow.

Observing a Chemical Change

	Reactants	Products
general observations	very blue solution, silver-grey threads of iron	Steel wool and a blue colour disappeared as a reddish-brown solid appeared. The colour was not the orange-brown colour of rust. The flask got quite warm in the area where the steel wool sat. The change continued for about five minutes until all of the steel wool was gone. Rusting is a very slow process. In the end, the solution was only faintly blue.
mass (g) of tightly sealed flask and contents	748	748

5. Answer question 1 of "Analyze" and question 4 of "Conclude and Apply" from page 109 of the textbook.

6. Read the first part of question 6 of "Extend Your Skills," up to the end of the sentence "Why or why not?" Do not design or perform the investigation suggested in this textbook question.

   a. Could you create 10.5 g of carbon dioxide gas from the reactants? Explain.

b. Explain why it would be dangerous to perform the reaction in the sealed glass container used for the steel wool and copper (II) sulfate reaction.

c. If the vinegar and baking soda reaction took place in an open container, how would the final measured mass compare to the initial measured mass? This initial measured mass was determined before the reaction. Explain.

Talk to your teacher about disposing of waste products from the investigation.

Compare your responses with those in the Appendix on page 79.

end of investigation

There are many careers in which chemistry plays an important part. Do the "Going Further" to find out.

Going Further

Do some research. Try the "Career Connect" on page 109 of the textbook.

Continued Development

You likely take batteries for granted as you pop fresh ones into your portable CD player or game machine. Technology may be important for your entertainment, but it's critical for the progress of science.

Batteries became available in the late 1700s. Batteries opened up a new way of investigating matter. **Electrolysis** allowed compounds to be decomposed. Elements could be isolated.

electrolysis: the process of decomposing a compound by passing an electric current through it

Read "New Discoveries" on page 110 of the textbook.

7. The volume of hydrogen produced during the electrolysis process was twice the volume of oxygen produced. If you did the electrolysis in a laboratory today, would the ratio of hydrogen to oxygen be the same? Explain why.

8. Use either the word *inference* or *observation* to identify the following statements based on data collected from the electrolysis of water.

   a. The volume of hydrogen produced during the electrolysis of water was always twice the volume of oxygen produced.

   b. Water contains twice as many hydrogen atoms as oxygen atoms.

   c. Hydrogen atoms and oxygen atoms have different masses.

9. A mixture of pure hydrogen gas and pure oxygen gas react explosively when ignited by flames or electricity. Predict the product of this reaction.

10. How was Dalton's description of water incorrect?

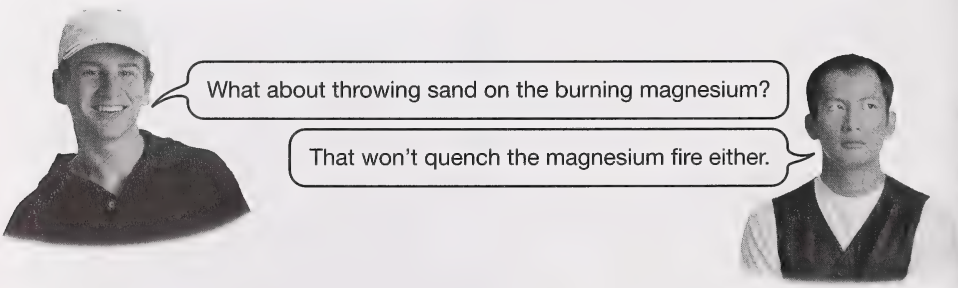
11. Both elements and compounds are made up of particles.

    a. Based on Dalton's atomic theory, what are two properties that atoms of the same element share?

    b. What is produced when atoms of different elements link together in a certain proportion?

Compare your responses with those in the Appendix on page 80.

Magnesium is an element. It is also a silvery white metal. It is strong enough to be used in airplanes and bridges. Yet, it is vulnerable to oxygen. Once it starts burning, oxygen reacts vigorously with magnesium. A lit ribbon of magnesium will even keep burning brilliantly under water. Even carbon dioxide, which suffocates most fires, has no effect on a magnesium fire.



Discover more about some elements in the next "Going Further."

Going Further

Use a search engine to look up chemical elements. Check these sites:

http://www.webelements.com
http://www.chemsoc.org/viselements

Use "Find Out Activity: Collect the Elements" on page 110 of the textbook.

Think of the following questions to guide your research:

- How is the element obtained or manufactured?
- What are its melting and boiling points?
- What is its density?
- How does it react with water or oxygen?

Share the information you find with friends and family members.

Observations, Laws, Theories, and Models

The Alberta Legislature in Edmonton is where laws are made for the province of Alberta. Scientific laws are different from those passed in Edmonton. Enacted laws indicate what people are supposed to do.

Scientific laws are not statements that indicate what is supposed to happen. Scientific laws just describe and summarize what does happen—based on many observations. Think of the law of gravity.

Scientific theories are different from scientific laws. Theories can explain why something happens or how something behaves. Cell theory, atomic theory, and the theory of plate tectonics are some scientific theories.

Read "Laws, Theories, Models, and Observations" on page 112 of your textbook.

12. Select a word from the reading for each of the following descriptions.

- **a.** describes and summarizes
- **b.** explains why
- **c.** helps picture structures or processes that cannot be seen directly
- **d.** more certain than a hypothesis

Compare your responses with those in the Appendix on page 80.

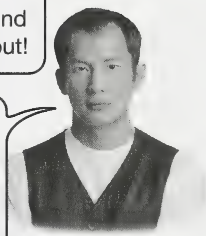
The Evolving Atomic Models

The atomic models changed as new information was discovered. Read "A Brief History of Atomic Models" on page 113 of the textbook and the items on page 114 to find out about the development of the atomic model.

13. Who was responsible for each of the following?

- **a.** the electron-shell atomic model
- **b.** discovering neutrons in the nucleus
- **c.** the electron cloud model
- **d.** "the plum pudding" model
- **e.** the planetary model (atomic nucleus)

Compare your responses with those in the Appendix on page 81.



14. Turn to page 114 of your textbook and answer questions 1 and 2 of "Topic 3 Review."

Compare your responses with those in the Appendix on page 81.

Looking Back

In this lesson you learned how knowledge grows through observation and investigation by many scientists. You saw how the law of conservation of mass applies to chemical changes. You looked at what evidence led to the discovery of elements and compounds. Dalton's atomic theory was an improvement on the particle theory of matter. Scientific knowledge grows through the development of laws, hypotheses, theories, and models.

Lesson 4: Wrap-up

Review the concepts you have learned by completing the following questions.

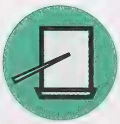
Turn to page 115 of your textbook and answer questions 1 to 5 and 11 of "Wrap-up: Topics 1 to 3."

Check your answers with your teacher or home instructor.

Section 1 Conclusion

In this section you did hands-on investigations to discover more about the make up of substances and their properties. While you explored substances, you practised safety procedures. You extended a classification of substances to include elements and compounds. And you developed appropriate scientific language and were introduced to concepts of atomic theory.

A bricklayer builds a wall from smaller parts made up of bricks and mortar. The wall is a model showing what you found in this section—that large things are made up of smaller things. Just like the brick wall, matter itself is composed of smaller parts. These tiny parts are called atoms.



Turn to Assignment Booklet 2A. Complete questions 6 to 11 from Section 1.

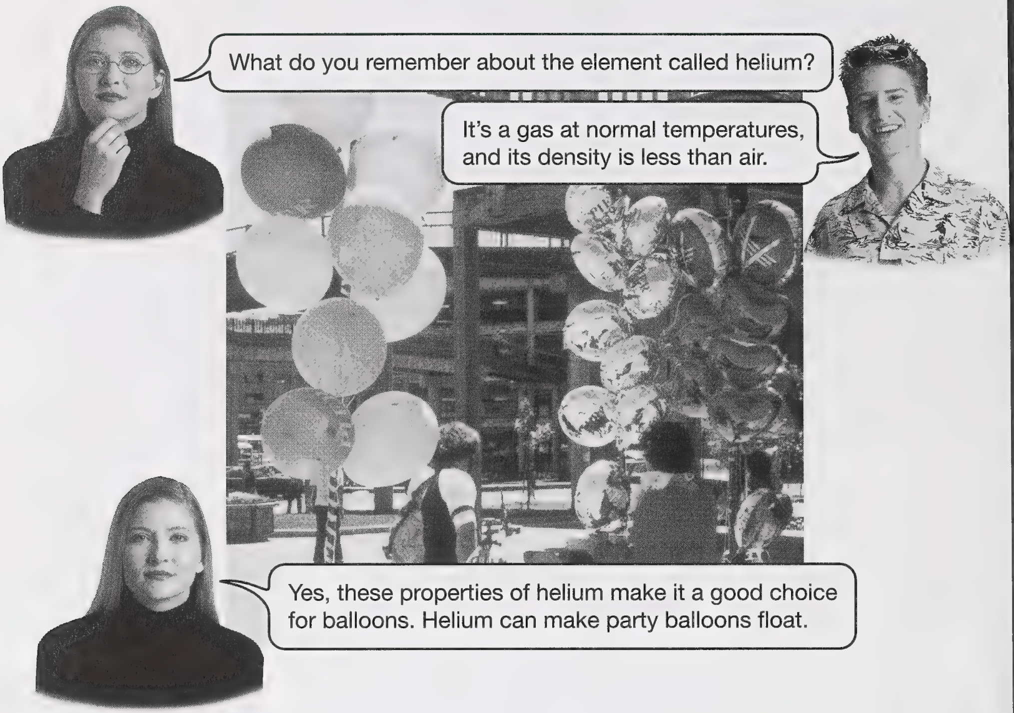
Section 2

The Chemical Nature of Matter

That soft ice cream cone does look delicious. You may not think of it as a collection of chemicals, but that's just what it is. Everything you eat, wear, and breathe, along with the products from which your home and furniture are built and decorated, the car you ride in, and the road you travel on are created from chemicals. These chemicals can come in the form of simple elements, or they may be complicated compounds.

In this section you will focus more closely on elements—both individually and as building blocks of matter. You will discover patterns in the properties of elements, identify families of elements with properties in common, and relate the properties of elements to atomic structures. You will also describe compounds as chemical combinations of elements, and you will write symbols for elements and compounds.

Lesson 1: Classifying Elements



Discovering properties of elements may show how the element can be used. The properties of elements also help in classifying them.

To talk about properties of elements, it's helpful to agree on symbols for elements.

Turn to page 116 of the textbook and read "Element Symbols."

1. Why are element symbols important to scientific communication around the world?

Compare your response with the one in the Appendix on page 81.

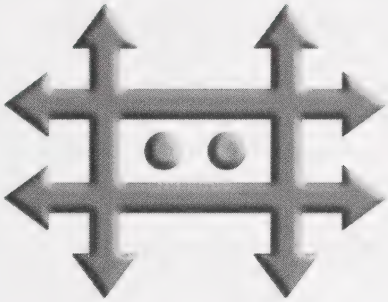
Do you know anyone who has had a joint replaced? The strong, light, and non-reactive titanium metal in artificial hip joints can be identified around the world by the symbol *Ti*. The next activity gives you a chance to get better acquainted with many elements and their symbols.

Find Out Activity Symbols for Elements

Refer to the activity on page 117 of the textbook. Use “Appendix B” and “Appendix C” on pages 440 to 445 of the textbook to help you answer the questions.

2. Answer “Procedure” questions 1 to 5.

Compare your responses with those in the Appendix on page 82.



The ancient symbol for zinc reflects the mystical nature of alchemy.

When zinc burns, it can form a white, fluffy substance. Philosophers’ wool is an ancient name for this substance.

Find out more about elements and how they are named in the next “Going Further.”

Going Further

Follow the “Computer Connect” on page 116 of the textbook.

You can use your research to complete element information cards. You can add to the collection you may have started in a previous “Going Further.”

Grouping Elements

When you studied living things, you placed them in groups. This helped you make sense of their variety. Many living things can be placed in the large animal and plant kingdoms. Grouping things helps make sense of them.

Elements can be considered to be in just three groups.

Turn to page 118 of the textbook and read "Different Kinds of Elements." Include "Did You Know?" in your reading.

3. How many individual elements have been identified?

4. There are three kinds of elements.

- **a.** Name these three groups of elements.
- **b.** Which of these groups has the most elements?
- **c.** Which element of the metalloids is the most abundant in Earth's crust?
- **d.** Which kind of element is solid, brittle, and not ductile?

Compare your responses with those in the Appendix on page 82.

Chemical Families

There's not just one way to classify the elements.

Turn to page 120 of the textbook and read "Chemical Families." Families are smaller than the three groupings you used before.

5. You've seen that elements can be classified as belonging to one of three kinds. Name a different, more specific way to further classify elements.

In the next activity you will explore similarities and differences within the metal group.

Find Out Activity A Chemical Family

Refer to the activity on page 120 of the textbook.

6. Answer questions 1, 3, and 4 of "Procedure."

Compare your responses with those in the Appendix on page 82.

Calcium is an extremely important part of your bones. Calcium is a metal. Does that surprise you? You may be astonished by some of the other "metallic" facts as you read "Alkali Metals" and "Alkaline Earth Metals" on page 121 of the textbook.

Note: After this reading you may be concerned about the reactivity of calcium that you carry in your bones. But don't worry. The calcium in your bones is in an ionic form. In this form, calcium is stable. You'll learn about the ionic form of compounds in Lesson 3.

7. Why are alkali metals reactive?

8. Name a metal you can easily burn.

Turn to "Inquiry Investigation 2C: Ready to React" on page 122 of the textbook.

Read the introductory paragraph, as well as "Question" and "Hypothesis." You earlier studied the production of copper and iron (II) sulfate. Copper is an element, while iron (II) sulfate is a compound. This production occurred in a similar displacement reaction—between iron and copper (II) sulfate.

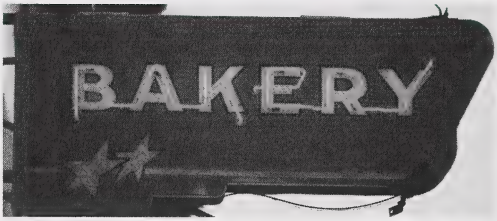
Note that hydrochloric acid is just a **catalyst** in this investigation. Look up the definition of catalyst.

9. **a.** Write your own specific hypothesis for the investigation.
b. Predict the products of the reaction.

Compare your responses with those in the Appendix on page 83.

Two More Chemical Families: Noble Gases and Halogens

You have probably seen neon lights used for all kinds of electric signs. Neon belongs to the chemical family of Noble Gases. Read “The Noble Gases” and “The Halogens” on pages 124 and 125 of your textbook.



10. The element argon was the first noble gas to be discovered.

- **a.** What is the main characteristic of a noble gas?
- **b.** Why do they all have this characteristic?

11. How did Neil Bartlett contribute to the development of chemical knowledge?

12. Why are the halogens reactive?

13. Name two ways in which chlorine, bromine, and iodine differ.

Compare your responses with those in the Appendix on page 83.

Go to the *Science 9 Multimedia* CD. There you can revisit chemical families and their properties. Play the CD on a computer. Once the menu screen appears, select the title “Chemical Glossary.” Then you can choose “Halogens,” “Metal,” “Metalloid,” and “Noble Gases.” You’ll see illustrations and descriptions to help you understand.

14. Turn to page 125 of your textbook and answer questions 2 and 3 of “Topic 4 Review.”

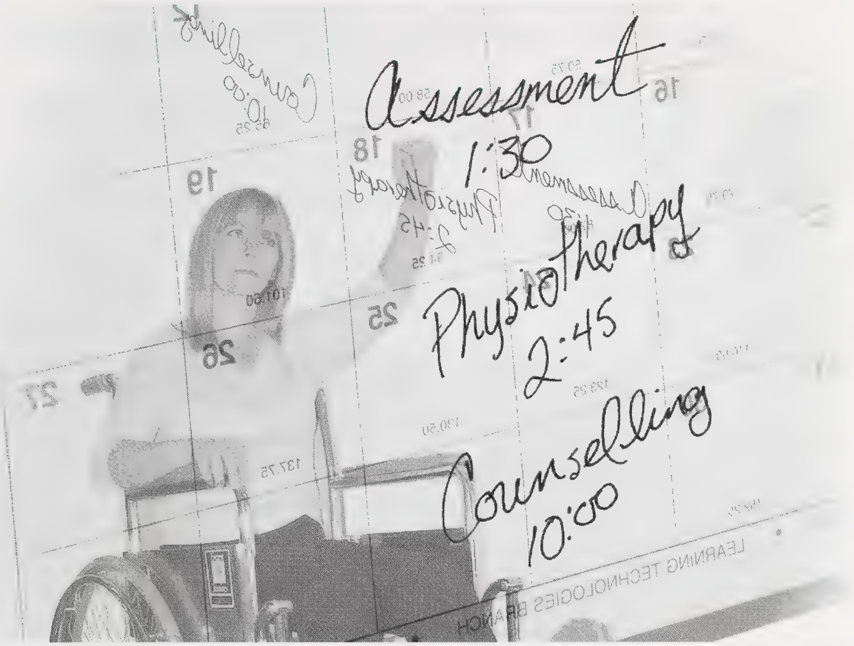
Compare your responses with those in the Appendix on page 83.

Looking Back

In this lesson you were introduced to chemical elements. You studied their chemical symbols, and you classified elements according to their properties.

Turn to Assignment Booklet 2A. Complete questions 1 and 2 from Section 2.

Lesson 2: The Periodic Table



Do you mark important events on a calendar? Placing volleyball games, parties, medical appointments, or other important events on a calendar helps you stay organized, doesn't it?

When the days of a month are placed in increasing order in a table, they repeat on a weekly basis. Jump forward seven days and you end up on the same day of the week.

The elements can be organized in a table according to a property of their atoms. Like a calendar, the table of elements will also show a kind of repetition. As well, the table serves as a kind of graphic organizer.

Read pages 126 and 127 of the textbook to find out how the **periodic** table of elements was developed. Find out the role of **atomic mass** in the ordering of the elements.

periodic: *recurring at regular intervals*

atomic mass: *the average mass of the atoms of an element*

1. Dmitri Mendeleev made cards for each element. He ordered the elements as others had done before him.

a. What did Mendeleev look for as he created the periodic table?

b. What did he do that the others had not done in trying to organize the elements?

c. What led Mendeleev to predict the existence of elements that had not even been discovered yet?

2. Why is gallium a particularly curious metallic element?

Read page 128 of the textbook for more information on the development of the periodic table of elements.

3. Mendeleev based his periodic table on atomic mass. What is the basis of the modern periodic table?

4. Read the following data table.

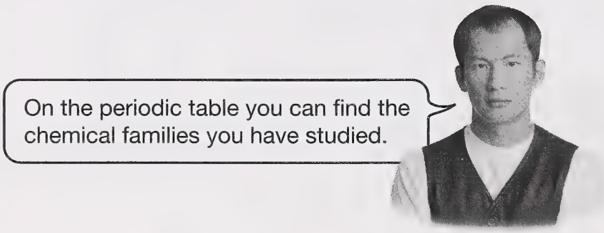
Characteristics of Elements			
Element	**Atomic Number**	**Atomic Mass**	**Mass Number**
hydrogen	1	1.008	1
helium	2	4.003	4
lithium	3	6.941	6
oxygen	8	15.999	16

Based on the data table, infer a relationship between atomic mass and mass number.

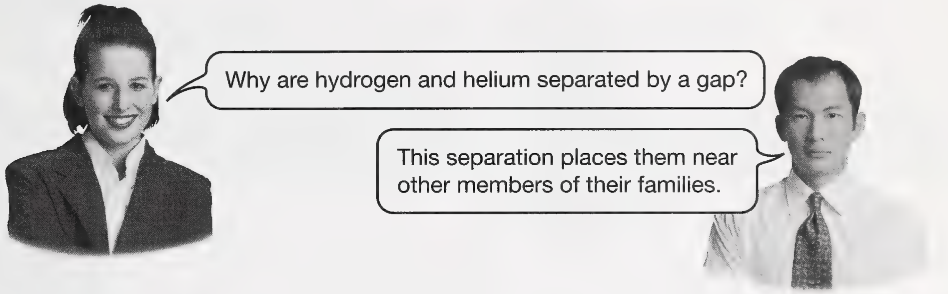
5. Neon has an atomic number of 10. How many electrons does a neutral atom of neon have?

Compare your responses with those in the Appendix on page 84.

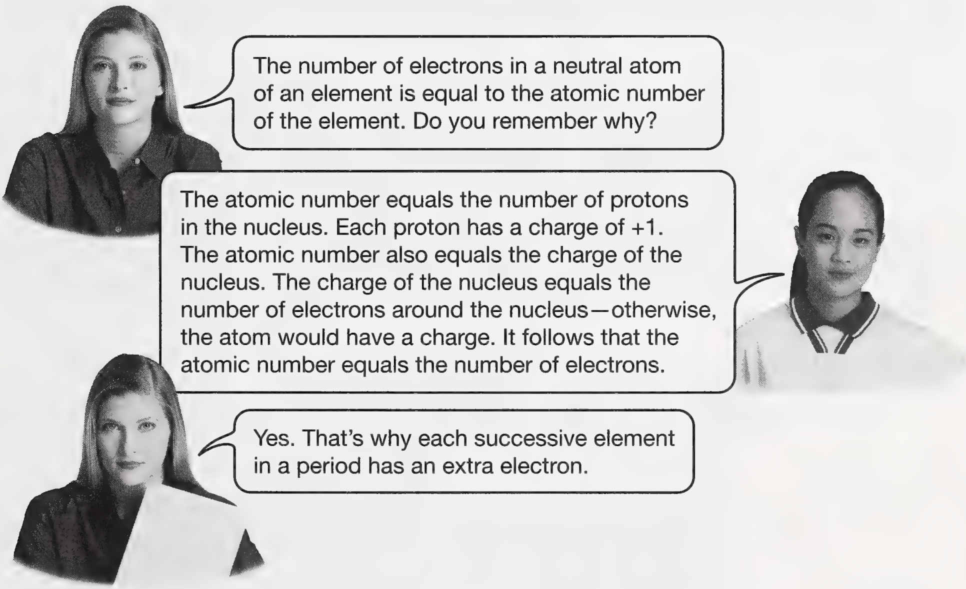
Refer to the "Periodic Table of the Elements" on pages 132 and 133 of the textbook. There's another example to look at in "Appendix B: Periodic Table of the Elements" on pages 440 and 441 of the textbook.



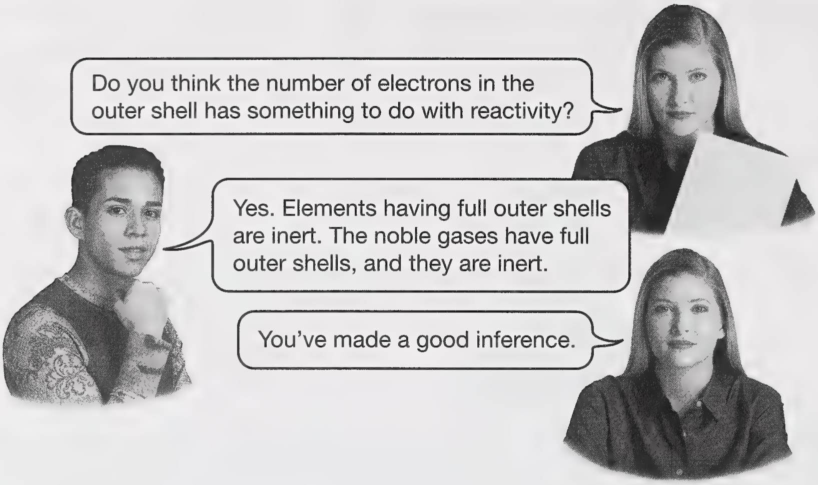
The periodic table organizes all the elements to show patterns in properties. Each horizontal row of the table is called a period. Each period starts with a reactive alkali metal and ends with an unreactive noble gas. There is a progression from metals to non-metals along each period.



The vertical columns in the table are known as groups. Elements of a chemical family are in the same column or group. The first column contains the alkali metal family. The second column contains the alkaline earth metal family. The right-hand column has the noble gas family.



The electrons of an atom are arranged in layers or shells. As you move along a period or row of the periodic table, the atoms of the elements gain electrons in their outer shell. An alkali metal has just one electron in its outer shell. By the time you get to the noble gas family at the other end of the period, the outer shell is completely full.



The element following the noble gas is in the next period or row farther down. The elements in the new period have a new outer layer. This outer layer also fills up as you go along the period.

Do the next "Going Further" to become more familiar with the periodic table.

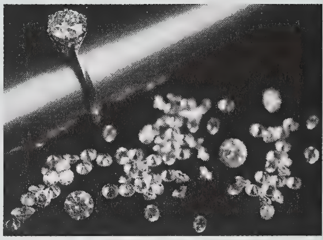
Going Further

Get out your ruler and create your own version of the periodic table!

Follow the directions for "Think and Link Investigation 2D: Meet the Modern Periodic Table" on pages 129 to 131 of the textbook.

DID YOU KNOW?

When it's transparent and free from flaws, a diamond is highly valued as a precious stone. Nevertheless, a diamond is just a form of carbon, along with charcoal and graphite.



Turn to page 134 of your textbook. Look at "Figure 2.37." Graphite and diamonds are shown as different forms of carbon.

6. Turn to page 135 of your textbook and answer questions 2, 4, and 5 of "Topic 5 Review."

Refer to pages 440 to 445 of the textbook.

7. **a.** Infer the relationship between the atomic mass and the density of an element.
   b. Provide a specific example to back up your inference.

Compare your responses with those in the Appendix on page 84.

Looking Back

You have discovered that the properties of elements repeat in cycles. This repetition is shown in the periodic table of elements. In the periodic table the elements are ordered by their atomic number. With this ordering, families of elements become columns or groups in the periodic table.

Turn to Assignment Booklet 2A. Complete questions 3 to 8 from Section 2.

Lesson 3: Chemical Compounds

You probably don't think of water as a chemical. But it is. Suppose someone offered you some cold liquid H_2O to quench your thirst—that person would be offering you water using its chemical formula.

The chemical formula H_2O suggests that water contains both hydrogen and oxygen. And water does indeed contain these elements. Water is a chemical **compound**.

***compound:** a pure substance that is made up of two or more elements which are chemically combined*

Turn to page 136 of the textbook and read the top part of the page and "Understanding Formulas for Compounds."

1. Indicate which statement describes ionic compounds and which describes molecular compounds. Write down "I" for ionic or "M" for molecular for each statement. Write these answers in your notebook.

   a. An aquatic solution of this type of compound does not conduct electricity. ______

b. Atoms of one element give electrons to atoms of the other element during the formation of this type of compound. ______

c. This type of compound conducts electricity when in solution. ______

d. This type of compound is a solid at room temperature. ______

e. This type of compound is generally formed from only elements on the right side of the periodic table. ______

f. It does not form ions when dissolving in water. ______

g. It forms charged particles—or groups of charged particles—when in an aquatic solution. ______

h. This type is formed from the chemical combination of a metallic and a non-metallic element. ______

i. Its atoms share electrons rather than transferring them. ______

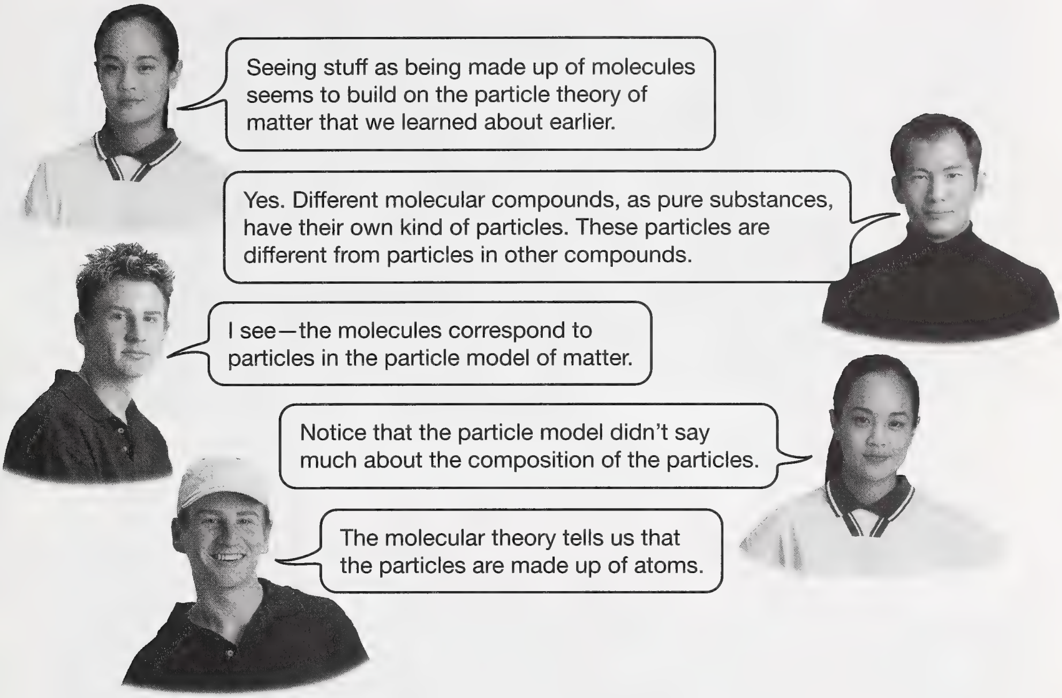
2. Aluminum is made from a substance called alumina, which has the formula Al_2O_3.

   a. Based on the formula, what are the two elements in alumina?
   b. In what ratio of atoms do these elements occur in a sample of alumina?

Compare your responses with those in the Appendix on page 85.

As you found out, compounds can be molecular or ionic.

Turn to pages 136 to 138 of the textbook and read "How Are Molecular Compounds Named?" and "Molecular Compounds."



3. Write formulas for the following molecular compounds.

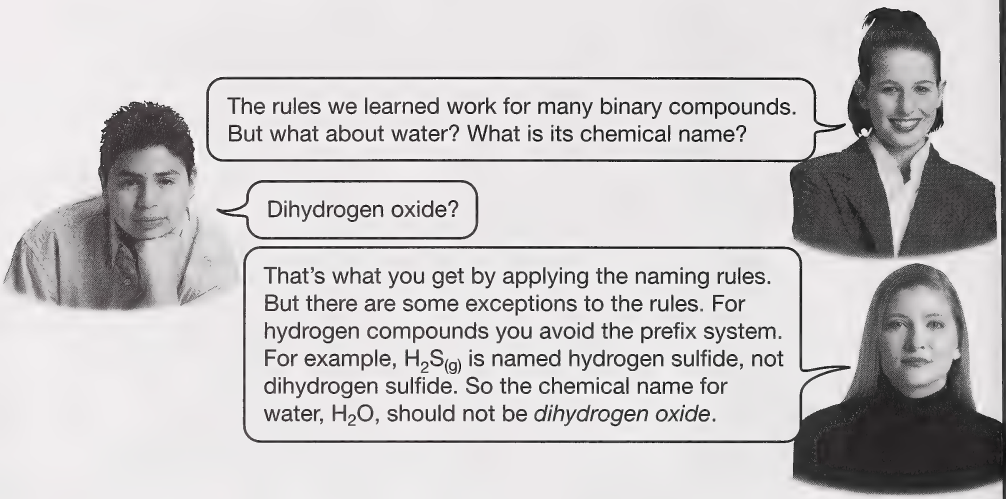
   a. carbon dioxide
   b. carbon disulphide
   c. carbon monoxide
   d. carbon tetrachloride
   e. dinitrogen oxide
   f. nitrogen triiodide
   g. tetraphosphorus decaoxide

4. Write formulas for the following elements as diatomic gases.

   a. oxygen (as a diatomic molecule)
   b. nitrogen (as a diatomic molecule)

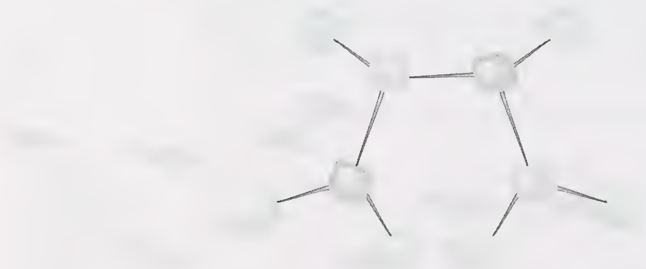
5. The formula of the molecular compound glucose is $C_6H_{12}O_6$. How many atoms are there in a molecule of glucose?

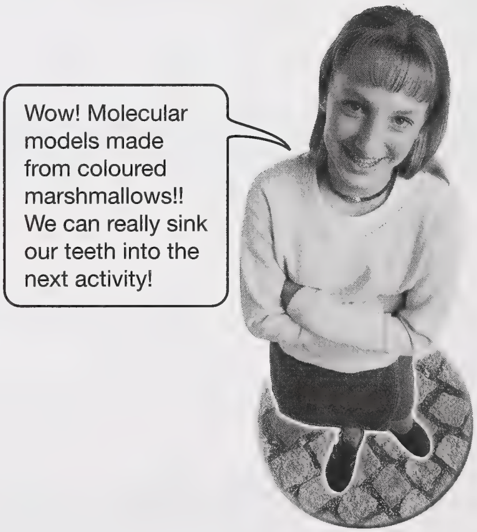
Compare your responses with those in the Appendix on page 85.



You don't have to know all the exceptions to the naming rules. But you should be prepared to see chemical names that you cannot analyze according to the naming rules you're familiar with.

Besides chemical names and formulas, you can use models to represent molecules. All you need are marshmallows and toothpicks for the next activity.





Find Out Activity Building Model Molecules

Refer to the activity on page 138 of the textbook.

Read the activity over. Follow the steps of "Procedure."

6. Answer questions 1 and 2 of "What Did You Find Out?" and question 3 of "Extend Your Skills."

Compare your responses with those in the Appendix on page 85.

Go to the *Science 9 Multimedia* CD for a look at some molecular models. Play the CD on a computer. Once the menu screen appears, select the title "Chemical Glossary." Then choose "Ammonia" and "Water." You'll see their molecular models. The rotation of these models gives you a three-dimensional sense of their structure.

Going Further

Do you enjoy a challenge? If so, try question 4 of "Extend Your Skills" on page 138 of the textbook.

Ionic Compounds

ion: an electrically charged atom or group of atoms due to a loss or gain of electrons

ionic compound: a compound formed when atoms transfer electrons to or from other atoms

In molecular compounds, atoms combine to form individual molecules. On the other hand, **ions** are the building blocks in **ionic compounds**.

Molecules are not formed in ionic compounds. In fact, ionic compounds do not have such definable units. Atoms give electrons to other atoms. This transfer of electrons causes the formation of ions. The ionic compound consists of ions held together in a crystal lattice structure. This structure holds many positive and negative ions and does not have a fixed size.

Do you reach for the salt and pepper shakers at mealtimes? The salt you shake onto your food is one of many ionic compounds that you use in your daily life.

Go to the *Science 9 Multimedia* CD for a look at some molecular models. Play the CD on a computer. Once the menu screen appears, select the title "Chemical Glossary." Then choose "Sodium Chloride." You'll see the structure of a salt crystal. You will see the one-to-one ratio of sodium and chlorine and get a three-dimensional sense of the structure.

Turn to page 140 of the textbook and read "Ionic Compounds."

7. How does an atom become an ion?

8. How could you test to see if a substance is an ionic compound?

Compare your responses with those in the Appendix on page 86.

DID YOU KNOW?

The word *ion* comes from the Greek word for wander. When ionic compounds are in solution, the ions can "wander" about. The mobility of ions allows solutions of ionic substances to conduct electricity.

When ionic substances are in a solid state, the ions are fixed in a lattice structure. In a solid ionic substance the ions can't wander—the substance is not a conductor of electricity.

Go to the *Science 9 Multimedia* CD for more information on conductivity and its use in identifying ionic substances. Play the CD on a computer. Once the menu screen appears, select the titles "Conductivity of Distilled Water," "Conductivity of Liquid Ionic Compounds," and "Conductivity of Ionic Compounds in Solution."

Turn to the textbook and read "How Are Ionic Compounds Named?" on page 141.

The naming rules are similar to those for binary molecular compounds:

- Write the entire name of the first element. (For an ionic compound, the first element is the metallic element.)

- Change the ending on the name of the second element to *ide*. (The second element is the non-metallic element.)

Note: Don't use prefixes (*mono-*, *di-*, *tri-*) to indicate the number of each type of atom. Look at the formula itself for this kind of information. In the formula, subscripts indicate the ratio of the ions that make up the compound.

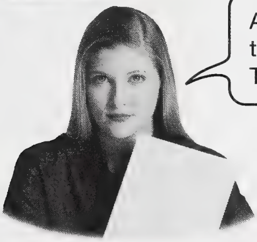
9. Write the chemical names of these ionic compounds.

a. $NaCl$
b. NaF
c. ZnS
d. $CaCl$

Compare your responses with those in the Appendix on page 86.

Some names of ionic compounds include a Roman numeral. This numeral shows the charge of the metal ion.

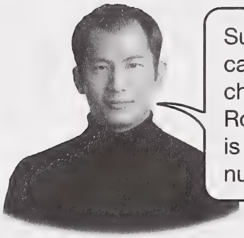
Isn't the charge for an ion fixed?



Actually, the atoms of some elements can take on one of two possible charge values. The resulting ions will have different charges.

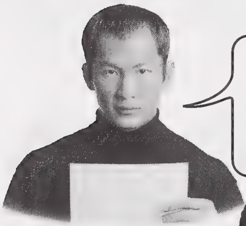
See the following data table.

Ions with More than One Possible Charge		
Element	**Possible Ion Charges**	**Possible Ions**
copper (Cu)	+1, +2	Cu^{+}, Cu^{2+}
iron (Fe)	+2, +3	Fe^{2+}, Fe^{3+}
lead (Pb)	+2, +4	Pb^{2+}, Pb^{4+}

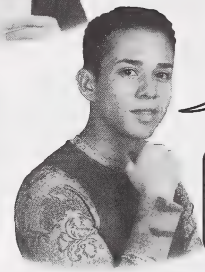


Suppose an ionic compound involves an element that can form ions with different charges. Then the chemical name of the ionic compound must include a Roman numeral to indicate which of the possible ions is involved. An example is iron (II) oxide. The Roman numeral shows that Fe^{2+} is involved, rather than Fe^{3+}.

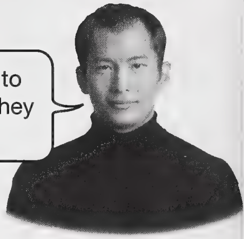
Why would you want to show the charge on the ion? It's just the composition we want.



Well, the charge on the ion actually affects the ratio of the elements in the compound. For example, compare iron (II) oxide and iron (III) oxide. The formula for iron (II) oxide is FeO. The formula for iron (III) oxide is Fe_2O_3.



I see. In iron (II) oxide the ratio of iron to oxygen ions is 1:1. In iron (III) oxide the ratio of iron to oxygen is 2 to 3.



Another reason for including the Roman numeral is to differentiate between the two forms of iron oxide. They are different compounds with different properties.

Turn ahead to page 159 of the textbook. Read "Did You Know?" for more information on the different forms of iron oxide.

10. From its chemical name, how can you tell if a chemical is an ionic compound?

11. Chlorine ionizes naturally only as Cl^-. An iron ion occurs naturally as Fe^{2+} or Fe^{3+}.

a. Write down the chemical formula for the compounds that could be produced if iron and chlorine reacted. Explain your reasoning.

b. Write the definite fixed ratios of elements for these two iron compounds.

Compare your responses with those in the Appendix on page 86.

Table salt is the ionic compound known as sodium chloride. Review the information about table salt on page 140 of the textbook as a background for the following activity.

Find Out Activity Formulas for Ionic Compounds

Refer to the activity on page 141 of the textbook.

12. Do "What Did You Find Out?" questions 1 to 3.

Compare your responses with those in the Appendix on page 87.

Salt and sugar look the same! But experience has taught you that they taste very different. How much do they differ chemically?

Salt and sugar represent ionic substances and molecular substances. Compare these kinds of substances in the next investigation.

If you have access to a teacher-supervised laboratory, carry out the steps of "Procedure" in this lab.

If you don't have access to a supervised lab, use the "Comparing Ionic and Molecular Properties" table of observations given to you in the following investigation.

Investigation 2F Comparing Ionic and Molecular Properties

Refer to the "Inquiry Investigation" on pages 142 and 143 of the textbook. Read through the entire investigation.

Note the following:

- Sucrose is more commonly known as *table sugar*.
- All substances were mixed with pure water, which is not in itself a conductor of electricity.
- The more ions present in a solution, the better it is at conducting electricity.

Refer to the following table if you don't have access to a teacher-supervised lab.

Comparing Ionic and Molecular Properties					
Substance	**Solubility in Water**	**Conductivity Test**	**Odour**	**Relative Hardness**	**Relative Melting Point**
sodium iodide	soluble	conductor	none	harder	high
copper (II) nitrate	soluble	conductor	none	harder	high
magnesium chloride	soluble	conductor	none	harder	high
graphite	insoluble	conductor	metallic	softer	medium
paraffin wax	insoluble	non-conductor	none	softer	low
sucrose	soluble	non-conductor	none	softer	low
starch	insoluble	non-conductor	none	softer	low

13. Answer questions 1 to 5(a) from "Analyze" and "Conclude and Apply."

14. Is graphite an elemental molecule or a molecular compound? Explain.

Compare your responses with those in the Appendix on page 87.

end of investigation

15. Turn to page 144 of your textbook and answer questions 1, 2, 3, 6, and 7 from "Topic 6 Review."

16. Identify the following as describing ionic compounds or molecular compounds. To the left of each letter, write down "I" for "Ionic" or "M" for "Molecular."

_______ **a.** When this type of compound is formed, electrons are transferred between atoms of one element to another.

_______ **b.** It conducts electricity when in solution.

_______ **c.** This type of compound is a solid at room temperature.

_______ **d.** It forms charged particles, or groups of charged particles, when in an aquatic solution.

_______ **e.** This type of compound is formed from the chemical combination of a metallic and a non-metallic element.

_______ **f.** An aquatic solution of this type of compound does not conduct electricity.

_______ **g.** This type of compound is generally formed only from elements on the right side of the periodic table.

_______ **h.** It does **not** form ions when dissolving in water.

_______ **i.** Rather than transferring electrons, its atoms share them.

Compare your responses with those in the Appendix on page 88.

Looking Back

In this lesson you compared the properties of molecular and ionic compounds and developed molecular models, chemical formulas, and names for compounds.

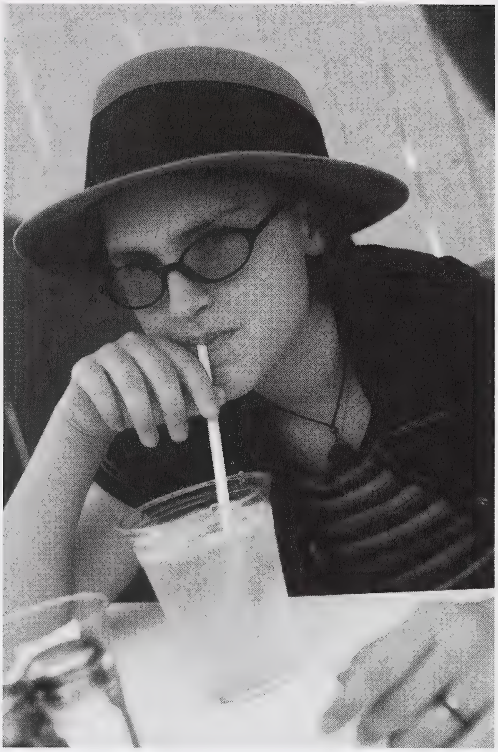
Lesson 4: Wrap-up

These questions will help you reflect on and apply the concepts in this section.

Turn to page 145 of your textbook and answer questions 1, 2, 3, 7, 8, and 10 of "Wrap-up: Topics 4 to 6."

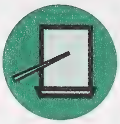
Check your answers with your teacher or home instructor.

Section 2 Conclusion



This section focused on elements. You discovered patterns in the properties of elements. There's a relationship between properties of an element and an element's position in the periodic table. You used the periodic table to relate an element's properties to its atomic structure. The periodic table helped you identify families of elements with properties in common. You described compounds as chemical combinations of elements. And you used chemical symbols to represent elements and compounds.

A cool beverage is refreshing! But as you drink, don't forget that you are ingesting a variety of chemicals. They include H_2O and maybe sucrose and citric acid. But don't be scared—all matter is a collection of chemicals.



Turn to Assignment Booklet 2A. Complete questions 9 to 16 from Section 2.

Section 3

Characteristics of Chemical Reactions

During blastoff, the rocket engines of a space shuttle produce a tremendous amount of energy. In the main engine, liquid hydrogen at a frigid – 253°C is burned with oxygen. Yet, the burning mixture reaches 3300°C. In the solid rocket boosters the temperature of the burning mixture becomes even higher. The shuttle is propelled from the launch pad by seven million pounds of thrust. This is more than the thrust of 35 jumbo jets at takeoff!

Where does this colossal amount of power come from? It comes from extremely fast and energetic chemical reactions.

In this section you will focus on chemical reactions. There are chemical reactions that release heat energy and other reactions that absorb heat energy. You will use a kind of shorthand—chemical equations—to represent reactions. You will also investigate factors that affect the speed of reactions. There are chemical reactions that launch space vehicles on long journeys. However, there are also many chemical reactions that are closer to home. Many of the reactions you will study are common to your everyday world.

Lesson 1: Chemical Reactions

chemical reaction: a process in which a substance is changed into one or more new substances

reactant: a substance that goes into a chemical reaction

product: a substance that is produced by a chemical reaction

Life depends on **chemical reactions**. When you're flying in a passenger plane, your pilot has an oxygen mask available in case of an emergency. There's also an oxygen mask that drops down for each of the passengers, if necessary. Oxygen is one of the **reactants** of chemical reactions that take place in the human body. The carbon dioxide you exhale is a **product** of chemical reactions.

Turn to pages 146 and 147 of the textbook, and read the introduction to the topic of "Chemical Reactions." Look closely at the Figures from "2.48 A to D."

In a previous lesson you studied chemical changes. You read the list of clues to chemical changes on page 102 of the textbook. Chemical reactions are at the root of all chemical changes. That's why the clues to chemical changes mirror those of chemical reactions.

mnemonic device: a saying, formula, or rhyme, used as an aid in remembering

1. Rewrite the following sentence. Complete the blanks to make a **mnemonic device**.

In a chemical reaction, ____________ react to produce ____________.

2. List five common chemical reactions.

Compare your responses with those in the Appendix on page 89.

A glow stick or a light stick is giving off an eerie light as you hold it in your hand. Is a chemical reaction taking place? The next activity will help you answer that question.

Find Out Activity Is It a Chemical Reaction?

Refer to the activity on page 147 of the textbook.

If you have access to a teacher-supervised laboratory with the prepared stations to visit, follow the steps of "Procedure."

If you don't have access to a supervised lab with the prepared stations, visit the following five "stations."

Make a chart to record your observations and inferences about the nature of the change you observe. Include a column for the inference you will make about whether there was a chemical reaction or just a physical change.

Remember to wear safety goggles!

Station I

Ask your home instructor or teacher to place a candle in a candleholder. Have your home instructor or teacher light the candle and stay to supervise. An open flame is a potential hazard. Keep long hair tied back. Be careful when you're near the flame.

Observe the burning candle and record what you see in your chart.

Station II

Place and observe a small piece of frozen, flavoured water in a dish. Record your observations after several minutes.

Station III

Place about 200 mL of water in a 250-mL measuring cup. Place about 5 mL or 1 teaspoon of sugar in with the water. Stir with a spoon for approximately 1 minute. Record your observations in your chart.

Station IV

Place a commercial antacid tablet into a small, self-sealing plastic bag. Using the back of a spoon, crush the tablet inside the plastic bag. Scoop out the powder and place the powder in a glass of water. Record your observations.

Station V

Place some water in a pot. Bring the water to a boil on a cooking stove. Record your observations.

3. Complete questions 1 to 4 of "What Did You Find Out?" on page 147 of the textbook.

Compare your responses with those in the Appendix on page 89.

chemiluminescence: the emission of light resulting from a chemical action

A light stick gives off light due to the energy released by a chemical reaction. You may have been able to infer that a chemical change was involved. The light is due to **chemiluminescence**. Do you remember this term from a previous science course?

Going Further

For more data about light sticks, go to the following site:

http://www.howstuffworks.com

Then type in "light sticks" from the "What are you searching for?" box. You'll find some good, specific information.

Chemical Equations

Shorthand is a way of writing quickly by substituting characters, abbreviations, or symbols for letters, sounds, words, or phrases.

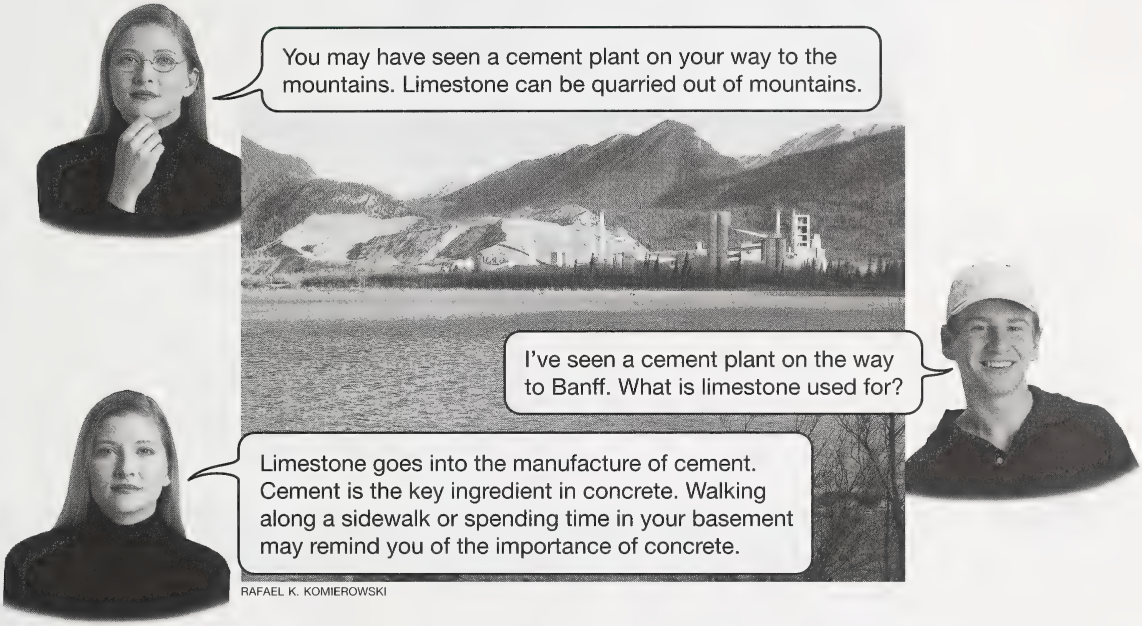
There's also a way to write chemical equations by substituting symbols for words. The result is a chemical equation.

Turn to page 148 of the textbook and read "Chemical Equations."

4. Turn to page 152 of the textbook and answer questions 2 and 4 from "Topic 7 Review."

Compare your responses with those in the Appendix on page 90.

Breaking Bonds



RAFAEL K. KOMIEROWSKI

Cement is manufactured by the process of chemically decomposing limestone to make calcium oxide (also known as lime). The chemical reaction requires energy. Why? The short answer is chemical bonds.

Turn to pages 149 and 150 of the textbook and read "Breaking Chemical Bonds." The reaction that describes the decomposition of limestone is

$$CaCO_{3(s)} + \text{energy} \rightarrow CaO_{(s)} + CO_{2(g)}$$

endothermic: *characterized by the absorption of energy*

exothermic: *characterized by the release of energy*

The reaction is **endothermic** because bonds are broken to free up carbon dioxide, $CO_{2(g)}$, from the reactant $CaCO_{3(s)}$. Breaking bonds requires energy.

Combustion is a familiar **exothermic** reaction. It releases energy because the bond formation in combustion releases more energy than is used for breaking bonds.

5. Complete the following statements.

   a. In a reaction, atoms are neither lost nor created. They just change __________.

   b. Forces that cause a group of atoms to act as a unit are called __________.

   c. Chemical bonds store __________.

   d. Energy is __________ when bonds break and __________ when bonds form.

   e. All chemical reactions involve __________ changes.

   f. __________ reactions release heat, light, sound, chemical, or electrical energy.

   g. __________ reactions absorb energy.

   h. The definite fixed ratio for nitroglycerin would be __________.

6. Turn to page 152 of your textbook and answer questions 1 and 3 from "Topic 7 Review."

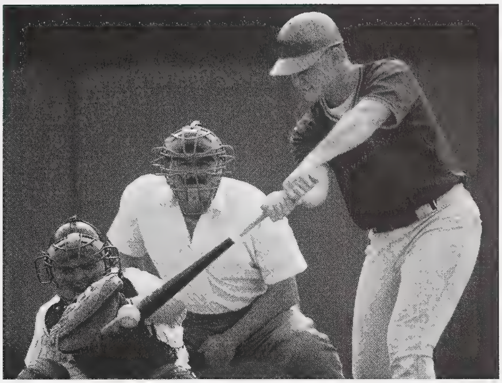
Compare your responses with those in the Appendix on page 90.

Looking Back

In this lesson you identified chemical reactions and distinguished between exothermic and endothermic reactions. Also, you used chemical equations to represent reactions.

Turn to Assignment Booklet 2B. Complete questions 1 to 5 from Section 3.

Lesson 2: Reaction Rate



A professional baseball player must react to a pitched ball in less than half-a-second after it leaves the pitcher's hand. If the reaction time is slower than this, the batter has virtually no chance of getting a hit.

This time of less than half-a-second is far quicker than you could react to the ball if you just started playing the game as a grade 9 student. Fortunately, your reaction time is affected by factors such as age and experience. With maturation and practice, your reaction time "speeds up."

There are also factors that affect the speed of chemical reactions.

Turn to page 153 of the textbook. Read the introduction of "Topic 8: Reaction Rate."

1. Write down three ways to increase the **reaction rate**.

reaction rate: the measure of how fast a reaction occurs

In the next activity you will apply your knowledge about factors that affect reaction rates.

Find Out Activity Changing with the Times

Refer to the activity on page 154 of the textbook. Note that you won't physically carry out the investigation.

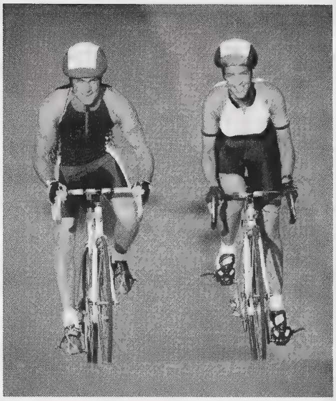
2. Give your predictions for steps 1 and 2 of "Procedure."

3. Answer "What Did You Find Out?" questions 1 to 3.

Compare your responses with those in the Appendix on page 91.

catalyst: a substance that speeds up the rate of a reaction without being changed itself

inhibitor: a substance that slows down or prevents a reaction without changing itself



Whether you ride a bike or drive a car, you want to be able to control the vehicle's speed. You don't want to either go at a breakneck speed or at a snail's pace. For chemical reactions to be useful, some may have to be speeded up but some others have to be slowed down. The presence of special substances called **catalysts** and **inhibitors** can control the speed of reactions.

Turn to page 155 of the textbook and read "Speeding Up a Reaction with Catalysts" and "Slowing Down a Reaction with Inhibitors." Include "Did You Know?" in your reading.

4. Why is an inhibitor added to hydrogen peroxide solutions?

5. Meat tenderizers and contact lens cleaning solutions contain enzymes called ____________ to break down proteins.

Compare your responses with those in the Appendix on page 92.

oxidation: a chemical reaction in which oxygen is a reactant

Note: This is a simplified definition. There are oxidation reactions that do not involve oxygen.

Reacting with Oxygen

Living things depend on oxygen in their surroundings. They use oxygen for cellular respiration. Glucose from food undergoes **oxidation** to produce water, carbon dioxide, and, very importantly, energy. It is the energy from this reaction that keeps your body warm—sort of as if each of your many cells were a tiny fireplace.

However, there are many oxidation reactions that are problematic. Just think of a rusty car fender, a rusty pair of scissors, a piece of apple turned a brown colour, or a rusted-out metal pail.

DID YOU KNOW?

Do you like to cut an apple into pieces before you eat it? If you do, you have probably noticed that the flesh of the apple turns brown when it's exposed to air for awhile. The apple turns brown due to oxidation.

If you want to prepare a salad with pieces of apple in it, dip the apple chunks into orange juice. The juice will help keep the apple from going brown before the salad is eaten.

What's the difference? Vitamin C in orange juice serves as an antioxidant, which is a substance that inhibits oxidation.

Metals oxidize. Some metals oxidize so well that they will burn. Do you remember magnesium, a member of the alkaline earth metals? It burns with an intense white light. This is shown in "Figure 2.28" on page 121 of your textbook. Iron will also burn, but only in the presence of pure oxygen or if the iron is in small enough pieces, such as iron filings. Usually, iron just oxidizes slowly to form **rust**. Rusting is one type of corrosion. You can imagine that you'd want to be able to slow down or prevent chemical reactions that lead to **corrosion**.

rust: *the reddish, brittle coating on iron due to oxidation*

Rust is a form of iron oxide that's a product of the chemical reaction between iron, oxygen, and moisture.

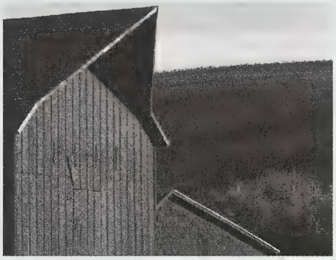
corrosion: *the process by which metal or stone is broken down*

Turn to pages 158 and 159 of the textbook and read "Corrosion" and "Preventing Corrosion."

DID YOU KNOW?

A protective oxide is common to corrosion resistant metals. For example, copper oxide adheres tightly to the surface of the copper to protect it from further damage. The oxide gives a copper roof its green hue. Copper roofs can last the lifetime of the building. Chrome and zinc also form protective oxides, which give the metals corrosion resistance.

Rust is an oxide of iron. Rust does not protect the iron underneath from more corrosion. However, iron oxides have interesting properties and even have important uses.



Read "Did You Know" on page 159 of the textbook.

6. List five ways to decrease corrosion.

Compare your responses with those in the Appendix on page 92.

In the next "Going Further" you can observe air being used up as iron oxidizes. However, you will have to be able to leave your materials in place for at least two weeks. Iron oxidizes slowly—at least while you're watching it. Continue with this science course in the meantime.

Going Further

Read "Find Out Activity: Corrosion Collection" on page 158 of the textbook. Follow the steps of "Procedure."

7. Answer "What Did You Find Out?" questions 1, 3, and 5.

Compare your responses with those in the Appendix on page 92.

combustion: *a highly exothermic reaction of a substance with oxygen*

Combustion and corrosion are both oxidation reactions. But combustion is a fast reaction in comparison to corrosion. Any corrosion is generally harmful. Combustion reactions can be beneficial or harmful. For example, when combustion takes place in the furnace that heats your home, it's a beneficial reaction. When combustion takes the form of an uncontrolled forest fire, it's harmful.

Turn to page 159 of the textbook and read "Combustion."

Think of a candle burning. The reactants of combustion are oxygen and chemicals that serve as a fuel. As these reactants are used up, some products must be produced. With a candle, any products seem to disappear "into thin air." Are there really any products?

In the next investigation you will observe reactants being used up and products appearing. This will give you a first-hand insight into combustion.

Ask your home instructor or another adult to supervise and help with this investigation. The investigation involves an open flame which, even from a candle, is potentially hazardous.

Investigation 2I An Illuminating Experience

Refer to the "Inquiry Investigation" on pages 160 and 161 of the textbook.

Note that there are three parts to the investigation.

Part 1: The candle is made to burn in an upside-down jar. The jar's "mouth" is below the water's surface. If water rises, the volume of the gases inside the jar have decreased.

Part 2: A cold object is held just above the flame. You may use a large spoon. Look for something that ends up sticking to the bottom surface of the object. Record your observation of the bottom surface. And hold the cold object just barely in the flame to see what forms.

Part 3: An upside-down, funnel-like cone of aluminum foil is held above the flame. You may want your helper to hold the cone. The cone serves as a chimney. You light a match above the hole where gases escape.

Follow the steps of "Procedure" for parts 1 to 3.

8. Do questions 1 to 4 of "Analyze" and question 5 from "Conclude and Apply."

Compare your responses with those in the Appendix on page 93.

end of investigation

You're now ready to read "Products of Combustion" on page 162 of the textbook. In the reading, find out about other combustion reactions.

9. How are the reactions for the combustion of methane, acetylene, and propane similar?

10. What type of reaction is occurring in the flask found in "Figure 2.59" on page 158 of the textbook?

11. Incomplete combustion occurs when there is not enough oxygen available to react with all of the carbon being burned in the fuel. Name two products of incomplete combustion.

Compare your responses with those in the Appendix on page 93.

12. Turn to page 164 of your textbook and answer questions 3, 4, and 8 of "Topic 8 Review."

13. Read "Ask an Expert" on pages 166 and 167 of the textbook. List three ways in which a forensic technician could use chemistry to help solve a mystery.

Compare your responses with those in the Appendix on page 94.

Going Further

It's here—the end of another module and the beginning of the module's final "Going Further." Plan and perform your own chemical investigation to test your knowledge and your science skills. This investigation should be done only under the direct supervision of your home instructor.

Try "Design Your Own Investigation: Tough as Nails" on pages 168 and 169 of the textbook.

Looking Back

In this lesson you investigated reaction rates, with a focus on two classes of oxidation reactions—corrosion having the slower reaction rate and combustion the faster rate. You analyzed factors that affect the reaction rate. You studied the effect of catalysts and inhibitors. And you paid special attention to the ways of controlling the reaction rate of corrosion.

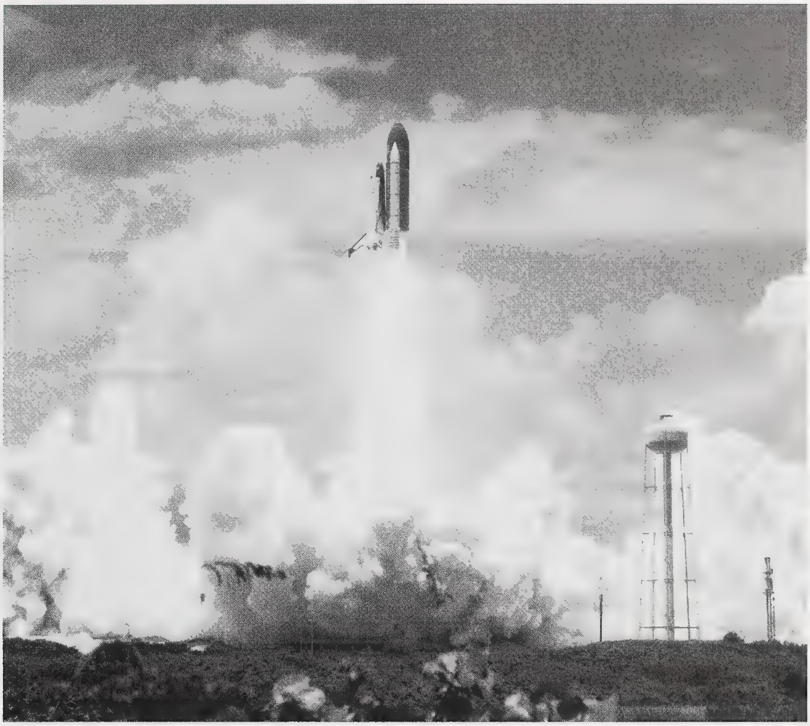
Lesson 3: Wrap-up

These questions will help you reflect on and apply the concepts from this section.

Turn to page 165 of your textbook and answer questions 1, 2, 5, and 7 of "Wrap-up: Topics 7 to 8."

Check your answers with your teacher or home instructor.

Section 3 Conclusion



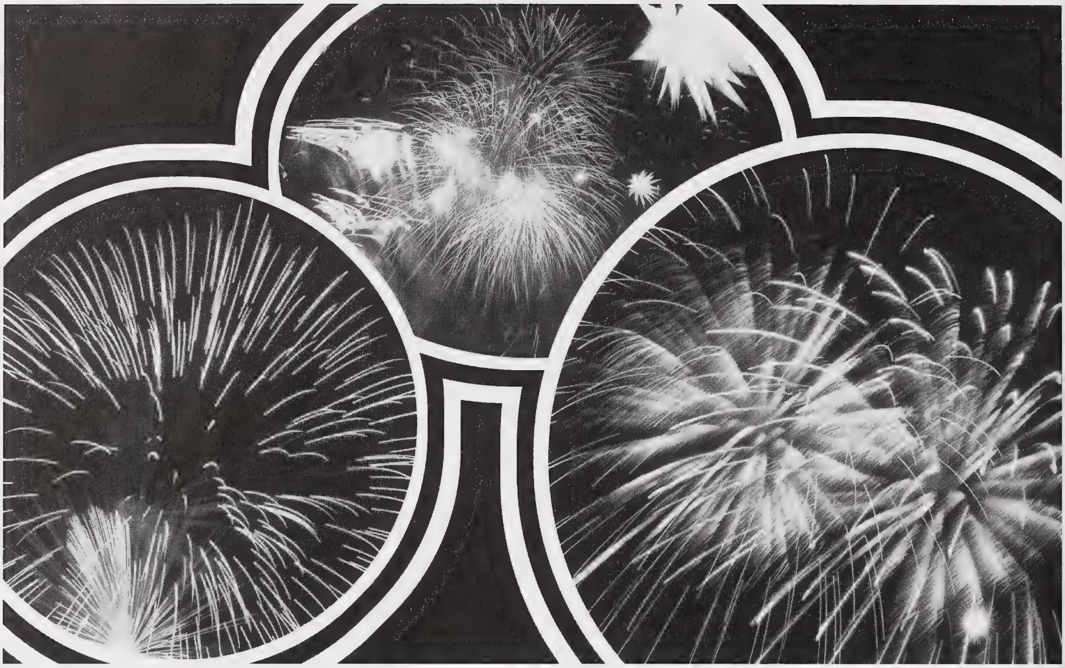
In this section you concentrated on chemical reactions. Using real world chemical reactions, you found that some reactions are exothermic and others are endothermic. You used chemical equations to represent reactions. You also studied the presence of catalysts, inhibitors, and other factors that control reaction rate.

You found that there are many real world chemical reactions close to home. There are also chemical reactions that launch vehicles out of this world into outer space.

At a space shuttle launch, there is evidence of enormous chemical changes taking place. There's bright light, thunderous sound, and palpable heat. There are powerful chemical reactions at work in the rocket engines. These reactions produce the thrust of a fleet of jumbo jets. Rocket scientists know how to control chemical reactions. This knowledge allows chemical reactions to be safely harnessed for many purposes.

Turn to Assignment Booklet 2B. Complete questions 6 and 7 from Section 3.

Module Summary



In this module you investigated materials in a systematic way. As an investigator you gained an awareness of the potential hazards of chemicals. You described materials in terms of their properties. You identified patterns in the reactions between substances. You appreciated the role of theoretical ideas in explaining observations. Ideas involving elements, compounds, and the periodic table were used to explain the properties of substances. You used the IUPAC system of naming to refer to substances. You identified chemical changes and used chemical equations to describe chemical reactions.

A fireworks' maker has to know about the properties of substances and how they interact. Such knowledge is based on ideas about the chemical nature of substances. The brilliant light and colours of a display depend on the substances the maker has put inside the shell.

Maybe you will see fireworks just after sunset on Canada Day, which is July 1st. The sight and sound of the fireworks going off will be impressive. The spectacular visual display will be amazing. What about the understanding of matter and chemical change that the fireworks' maker applies to the show? That's also amazing. It's this understanding that makes the display possible.

Module Review

The Module Review will help you review and apply what you studied and worked on in Module 2.

Let an interactive periodic table help you review the characteristics of elements and the structure of the periodic table of elements.

The *Science 9 Multimedia* CD is provided with this course. Play this CD on a computer. Once the menu screen appears, select the title "Periodic Table." Move your cursor over an element to discover its properties.

Before beginning the questions, carefully read and study the concepts listed in "Unit at a Glance" on page 170 of the textbook.

Answer questions 3, 8, 10, 11, 15, 24, 27, and 39 from "Unit 2 Review" on pages 170 to 173 of the textbook.

Check your answers with your teacher or home instructor.

Turn to Assignment Booklet 2B. Complete the Final Module Assignment.

Appendix

Glossary

Suggested Answers

Image Credits

Glossary

alkali metals: the first group (column) of the periodic table; highly reactive metals

alkaline-earth metals: the second group (column) of the periodic table; less reactive than alkali metals

aqueous solution: a solution that has water as the solvent

atom: the basic building block of matter; the smallest particle of an element that retains the properties of that element

An atom can be broken down into subatomic particles—electrons, protons, and neutrons.

atomic mass: the average mass of the atoms of an element

atomic nucleus: an atom's centre formed from protons and often neutrons

atomic number: the number of protons in an atom's nucleus

binary compound: molecules formed from two elements

catalyst: a substance that speeds up the rate of a reaction without being changed itself

caustic: a chemical that burns or damages living tissue

chemical change: a change in which one or more new chemical substances are formed

chemical family: a group of elements with similar properties

chemical formula: a set of symbols that represent the number and type of atoms in a molecule

chemical property: a characteristic that describes how a substance changes during a chemical reaction

chemical reaction: a process in which a substance is changed into one or more new substances

Bonds are broken in chemical reactions, atoms are rearranged, and new bonds are formed to produce new substances.

chemistry: the study of properties of matter and the changes matter undergoes

colloid: a heterogeneous mixture in which small, solid particles larger than dissolved particles do not settle but remain distributed throughout the mixture

combustion: a highly exothermic reaction of a substance with oxygen

This is also known as burning.

compound: a pure substance that is made up of two or more elements which are chemically combined

conductivity: the ability to transmit an electric current

corrosion: the process by which metal or stone is broken down

density: the amount of mass in a unit volume of a substance

diatomic molecules: molecules consisting of two atoms of the same element

electrolysis: the process of decomposing a compound by passing an electric current through it

electron: an extremely tiny, negatively charged atomic particle

element: a pure substance that contains only one type of atom

All elements have a unique number of protons in the nuclei of their atoms.

element symbol: one or two letters used internationally to represent a particular element

emulsion: a type of colloid in which liquids are dispersed in liquids

endothermic: characterized by the absorption of energy

enzyme: a specialized protein molecule that regulates chemical reactions in living things

exothermic: characterized by the release of energy

group: a column in the periodic table listing elements with similar chemical properties and the same number of electrons in its outer shell

halogens: the family of reactive gases grouped in the second last column of the periodic table

heterogeneous mixture: a non-uniform mixture in which two or more parts (phases) can be seen

Cloudy liquids are heterogeneous.

homogeneous mixture: a uniform mixture of two or more substances that looks like one substance (one phase)

inference: a conclusion or decision made by reasoning

inhibitor: a substance that slows down or prevents a reaction without changing itself

ion: an electrically charged atom or group of atoms due to a loss or gain of electrons

ionic compound: a compound formed when atoms transfer electrons to or from other atoms

mass number: the total number of protons and neutrons in the nucleus of an atom

matter: anything that has mass and occupies space

metal: a shiny, ductile, malleable element that conducts electricity

metalloids: elements that share properties with both the metals and the non-metals

mixture: a substance that consists of two or more pure substances

molecule: a particle formed from two or more chemically bonded atoms

Elemental molecules contain only one type of atom, while compound molecules contain two or more types of atoms.

neutron: an atomic particle that has no charge

noble gases: the family of stable, inert (non-reactive) gases grouped in the last column of the periodic table

non-aqueous solution: a solution that has a substance other than water as the solvent

non-metal: a family of dull, brittle, non-conductive elements

observation: the use of senses to gather information

The actual information is obtained through observation.

oxidation: a chemical reaction in which oxygen is a reactant

Note that this is a simplified defintion of oxidation suitable for this science course. But oxidation does not necessarily involve oxygen. Any chemical reaction involving a loss of electrons from an atom, ion, or molecule is an oxidation reaction.

period: a row of the periodic table

periodic: recurring at regular intervals

physical change: a change in form but not in chemical composition

In a physical change, no new substances are formed.

physical property: a property that can be observed or measured without a chemical reaction taking place

product: a substance that is produced by a chemical reaction

property: a characteristic of a substance that helps describe it

proton: a positively charged particle found in the nucleus of an atom

pure substance: matter that consists of only one type of particle

All the atoms or molecules of a pure substance are the same.

reactant: a substance that goes into a chemical reaction

A reactant is used up or broken apart in a chemical reaction.

reaction rate: the measure of how fast a reaction occurs

It's the speed of the reaction.

rust: the reddish, brittle coating on iron due to oxidation

Rust is a form of iron oxide that's a product of the chemical reaction between iron, oxygen, and moisture.

suspension: a heterogeneous mixture in which particles settle slowly after mixing

viscosity: the resistance of a fluid to flow

volume: the measurement of the amount of space occupied by a substance

weight: the force of gravity exerted on a mass

Suggested Answers

Section 1: Lesson 1

1. **a.** B **b.** A **c.** E **d.** D **e.** G **f.** F **g.** C

2. A mercury compound can start to be absorbed within just 15 seconds of its exposure to skin. Note that liquid mercury is not well absorbed through the skin. But harmful absorption of liquid mercury can occur if the skin is broken or if there is lengthy contact.

3. Caustic materials will burn, corrode, or otherwise destroy organic material.

4. **Textbook questions 1 to 3 from "What Did You Find Out?" on page 93:**

   1. Answers will vary. Examples include the following:

      - Corrosive Material
      - Flammable and Combustible Material
      - Poisonous and Infectious Material Causing Immediate and Serious Toxic Effects

   2. All of the "ScienceFocus 9" safety symbols are used in this module except the "Do Not" symbol and the "Sharp Object Safety" symbol. **Note:** See page 447 of the textbook for a complete list.

   3. Being aware of possible dangers is important to the health and safety of not only yourself and other people, but it's also vital for the environment.

5. Matter can be classified either by state (solid, liquid, gas) or by composition (pure substances, heterogeneous mixtures, homogeneous mixtures).

6.

Classifying Matter Based on Composition			
Sample Number	**Substance(s)**	**Number of Visible Components**	**Classification**
1	"gold" jewellery	**1**	**solution (alloy of copper and gold—pure gold is too soft to withstand wear)**
2	salt	**1**	**pure substance**

3	water	1	**pure substance**
4	oil and water	2	**heterogeneous mixture**
5	aluminum foil confetti, and coarsely crushed chalk	2	**heterogeneous mixture of two pure substances**
6	food colouring	1	**solution of water and vegetable dyes**
7	steeped tea without the leaves	1	**solution**
8	a mixture of coarse spices, e.g., oregano, parsley, dried onion	3	**heterogeneous (mechanical) mixture**

7. **Textbook questions 1 to 3 from "What Did You Find Out?" and "Extension," page 96:**

   1. Solutions look like they have only one type of matter. You can see two or more types of substances in a mechanical mixture—cloudy liquids contain tiny suspended particles. Both contain more than one substance.

   2. Answers will vary.

      The following is an example.

      The "gold" was difficult to classify because I didn't know it was made from a mixture of metals. The water was difficult because I wasn't sure whether or not anything was dissolved in it. And there are lots of clear, colourless liquids, such as rubbing alcohol and hydrogen peroxide.

   3. Answers will vary. Examples may include the following:

      - Ketchup is heterogeneous—it's composed of water with small tomato particles and a variety of seasonings.
      - Milk is heterogeneous—it's a cloudy liquid.
      - Italian salad dressing is a mixture of oil, water, and coarse spices—the water is a solution with sugar and salt.
      - Canola oil is a pure substance.

      Mixtures in the fridge are more common than pure substances.

8. **Textbook questions 4 and 5 from "Topic 1 Review," page 98:**

4. **(a)** Soil is heterogeneous, or a mechanical mixture, because you can see more than one part.

   (b) Perfume is a solution, or homogeneous. You can see only one part, but perfume is a mixture of ingredients.

   (c) Baking powder is a pure substance. You can see only one part. It contains only one substance/chemical. The atoms are "chemically bonded." It has a chemical formula and a name, $NaHCO_3$ (sodium hydrogen carbonate). Baking powder also has its own specific physical and chemical properties that can be used to describe or identify it.

   (d) Glass cleaner is a solution. You can see only one part, but it contains more than one component.

5. **(a)** Answers will vary. An example is air, which is a mixture of nitrogen, hydrogen, oxygen, water vapour, carbon dioxide, and other items.

   (b) Answers will vary. An example is carbonated beverages, where carbon dioxide is dissolved under pressure in water.

   (c) Answers will vary. An example is radiator fluid—water is dissolved in ethylene glycol or antifreeze.

Section 1: Lesson 2

1. **a.** This is a chemical change. As chlorophyll breaks down into other substances, other pigments in the leaves are exposed. It begins with one form of matter and ends with another.

   b. This is a physical change. There is a reversible change in location. It starts with one form of matter and ends with the same form of matter.

   c. This is a physical change. Although there is an irreversible change in size, it still starts with one form of matter and ends with the same form of matter.

   d. This is a chemical change. Carbon dioxide and water react chemically to produce sugar and oxygen—there is a start with one form of matter and an end with another form of matter.

   e. This is a chemical change. Sugar and oxygen react chemically to produce carbon dioxide and water. It starts with one form of matter and ends with another.

   f. This is a chemical change. Plant cellulose and oxygen react to produce carbon dioxide and water. It begins with one form or matter and ends with another.

g. There are only physical changes.

h. Only chemical changes result.

2. a. Chloride and sodium are left over.

   b. Sodium chloride may have formed—it's the chemical name for common salt or table salt. The salt dissolved into the water.

   c. The initial chemicals (reactants) traded parts to produce new chemicals. Calcium chloride and sodium carbonate reacted to produce calcium carbonate and sodium chloride.

3. **Textbook questions 4 to 8 of "Conclude and Apply" and "Extend Your Knowledge," page 101:**

   4. Chemical changes occurred when calcium chloride and sodium carbonate solutions reacted to produce calcium carbonate and sodium chloride in Part 1. Hydrochloric acid reacted with the calcite in Part 3 to produce bubbles of carbon dioxide plus calcium chloride. You started out with calcium chloride in Part 1.

   5. Physical changes occurred when the precipitate was filtered out of the mixture in Part 2 and when the salt and water were separated by evaporation in Part 3.

      Note: You may have considered the dissolving of the two chemicals in Part 1 to be physical changes. Strictly speaking, these changes are more than physical changes since ions are formed in the water. There's more on ions later in this module.

   6. A precipitate—calcium carbonate—formed in step 7 of Part 1. As the insoluble substance was produced it appeared in the liquid, then slowly settled to the bottom.

   7. Yes, the simulation illustrated how Alberta's carbonate rocks formed. It showed that chemicals dissolved in seawater could react to produce the mineral (calcite) from which limestone is formed. It also showed that the insoluble calcite precipitates out of solution and settles to the bottom, where it collects to form rock. **Note:** The acid test of Part 3 is used to identify the calcium carbonate produced in Part 1. An acid test is also used to identify limestone and dolomite.

   8. The salt deposits suggest ocean water covered the prairie provinces. The ocean water above ancient Alberta included many chemicals. The formation of a precipitate in this investigation was like the chemical change that led to the formation of limestone and other carbonates. Due to plate tectonics—such as faulting—the new limestone was pushed up to form the Rocky Mountains.

4. If you know a new substance(s) has formed, you can be sure there has been a chemical reaction. Any one of the other situations may be due to a physical change.

5. **Textbook question from "Figure 2.9," page 102:**

   The watermelon has experienced a physical change. It has been broken into smaller pieces, but new materials have not been produced.

6. A chemical property is a characteristic that describes how a substance changes during a chemical reaction.

   A physical property is a property that can be observed or measured without a chemical reaction taking place.

7. **Textbook questions from "Figure 2.10" and "Figure 2.11," pages 103 and 104:**

   a. When exposed to intense heat, hydrogen explodes and helium does not explode.

   b. Note the following answers:

   - reactivity of copper—chemical, qualitative
   - malleability of gold—physical, qualitative
   - reactivity of sulfur—chemical, qualitative
   - melting point of iron—physical, quantitative
   - ductility of solid material of wire—physical, qualitative

8. **Textbook questions 2 and 5 of "Topic 2 Review," page 105:**

   2. **(a)** This is a physical change. Sugar dissolving in water breaks into smaller pieces which move into the spaces between the water particles. The change starts with sugar and water and ends with sugar in water. There are no new substances.

      (b) This change is chemical. Highlights include the following:

      - colour and flexibility change
      - heat absorbed
      - new substance (cooked meat) formed (during cooking process a chemical reaction links protein molecules together)
      - cannot be reversed

      (c) There is no new substance for this physical change. The filament converts electrical energy into heat and light.

      (d) This is a physical change, and the change is in size only. A new substance isn't created.

      (e) A variety of new substances are produced that form leaves, a stem, and flowers. This is a chemical change.

5. Physical changes include freezing, drying, and being crushed or cut by the ice. Meanwhile, a chemical change includes biological decomposition.

   Scientists used a variety of clues to determine the age of the "ice man." The other organisms buried along with the man would be a physical clue, while the amount of decomposition would be a chemical clue. However, the most reliable indicator would be radioactive dating—based on a nuclear change—rather than any chemical or physical change.

Section 1: Lesson 3

1. According to Lavoisier's law of conservation of mass, the mass of the reactants is equal to the mass of the products. The mass of the wood and oxygen would equal the mass of the gases and other substances produced.

2. A *compound* is a pure substance made up of one or more chemically combined *elements*. An *element* is a pure substance that cannot be broken down into simpler substances through chemical change.

3. The properties and composition of pure substances are constant. **Note:** They can be measured and recorded in a data table. Because they are constant, they can be used to identify, describe, or group pure substances. The properties and composition of impure substances are not constant.

4. Answers will vary. An example is the following.

   The mass of the chemicals will remain the same throughout a chemical reaction. This is because atoms are not being added or removed. They are only being rearranged.

5. **Textbook question 1 of "Analyze" and question 4 of "Conclude and Apply," page 109:**

   1. Yes, a chemical change took place. Reasons include the following:

      - The blue colour got much lighter.
      - The steel wool disappeared.
      - A red-brown coloured substance appeared.
      - The reaction container got warmer.

      Note: You produced the element copper, as well as the compound iron (II) sulfate, in a displacement reaction between iron and copper (II) sulfate. The insoluble copper appeared as a precipitate in the solution. Iron (II) sulfate is soluble in water so it dissolved into solution as it was produced. Iron (II) sulfate is colourless. Copper (II) sulfate is blue.

4. Answers will vary. The following is an example.

   The masses were about the same for both reactants and products. Nothing could get into the container and nothing could get out of it, so the number of atoms in the container did not change.

   The container was sealed to prevent the loss of products or reactants. The weights were of reactants and then of products. Any material that did not take part in the reaction would be weighed both times so the comparison wouldn't be affected. The masses of the reactants and products were close or the same.

6. **a.** You could not create 10.5 g of carbon dioxide gas because the reaction also produces water and sodium acetate. The mass of all the products would exceed 10.5 g.

   b. When the liquid gas and solid baking soda are combined, a gas is rapidly produced. Because a gas requires a much larger volume for the same mass, the pressure inside the sealed container would rapidly increase. This could result in the glass container exploding.

   c. The final measured mass would be less than the initial measured mass because most of the carbon dioxide gas would escape into the air. You would not be including all of the products in the measured mass. That's because you would lose atoms to the surroundings.

   Note: In this investigation a reaction was chosen that could be safely contained in a sealed glass container.

7. The ratio of hydrogen to oxygen would be the same. The law of definite proportions says any compound contains elements combined in a fixed proportion. If the ratio were different, the compound would be something other than water.

8. **a.** Based on the collected data, observation will be used.
   b. Reasoning or inference must be involved because you cannot observe the atoms.
   c. Inference must be involved. You can't weigh atoms in a school laboratory.

9. Water is the product. This change, or reaction, is the reverse of water decomposition.

10. Dalton thought that water was composed of equal numbers of hydrogen atoms and oxygen atoms.

11. **a.** According to Dalton's atomic theory, all atoms of the same element are the same mass and the same size.

    b. A new compound is produced. All molecules of the new compound are the same mass, the same size, and have the same fixed proportions.

12. **a.** law **c.** model
    b. theory **d.** theory

13. **a.** Niels Bohr discovered the electron-shell atomic model.

    b. James Chadwick discovered neutrons in the nucleus.

    c. The electron cloud model was worked on by Louis de Broglie, Erwin Schrödinger, and other scientists.

    d. J. J. Thompson was responsible for the "plum pudding" model.

    e. Ernest Rutherford discovered the planetary model.

    Note: This model is also known as the Rutherford atomic model and the nuclear atom model.

14. **Textbook questions 1 and 2 of "Topic 3 Review," page 114:**

    1. Methods of scientific inquiry set guidelines for

    - conducting scientifically rigorous studies including appropriate ethics
    - collecting and documenting accurate data
    - sharing results and ideas
    - peer critiques of scientific studies

    Methods of scientific inquiry included experimentation, rechecking of results, and communicating results to other scientists. Proposed ideas were open to challenge by other scientists.

    2. Answers will vary. Note the following examples:

    - Law of conservation of mass—the mass of the reactants always equals the mass of the products.

    - Law of definite proportions—a compound is made up of elements always chemically bonded together in exactly the same way and in exactly the same proportions. This causes the compound's properties to be constant.

Section 1: Lesson 4

Check all the answers in this lesson with your teacher or home instructor.

Section 2: Lesson 1

1. While the pronunciation and spelling of the names of elements vary from language to language, the symbols are the same around the world. Having common symbols helps scientists communicate—even when different languages are involved. Science is an international activity.

2. **Textbook questions 1 to 5 of "Procedure," page 117:**

   1. Answers may vary. Boron, iodine, phosphorus, and uranium each have the first letter of their name as a symbol.

   2. **(a)** Carbon already has the symbol C.

      (b) Ca is the symbol for calcium.

      (c) Answers will vary. There are many possibilities, including

• lithium	• helium	• neon
• aluminum	• beryllium	• cobalt
• nickel	• silicon	• titanium

      You can see "Appendix B" or "Appendix C" of the textbook for other possibilities.

   3. **(a)** Their symbols are Ba, Be, Bi, and Br.
      (b) The symbol for berkelium is Bk.

   4. **(a)** Silver is Ag, gold is Au, copper is Cu, iron is Fe, mercury is Hg, lead is Pb, and tin is Sn.

      (b) Lead was used for Roman water pipes because its name *plumbum* includes the word *plumb*, which is in the word *plumber*.

   5. *Wolfram* was used as the basis for the symbol W.

3. More than 112 elements have been identified.

4. **a.** The three groups of elements are metals, non-metals, and metalloids.
   b. Metals have the most elements.
   c. Silicon is the most abundant element of the metalloids.
   d. Metalloids are solid, brittle, and not ductile.

5. Elements can be classified into chemical family groups.

6. **Textbook questions 1, 3, and 4 of "Procedure," page 120:**

   1. Answers should include three of the following:

      - They do not react with most acids.
      - They do not readily react with oxygen.
      - They are excellent conductors of electricity.
      - They are very or highly malleable.

3. **(a)** Iron conducts electricity. It is malleable but to a lesser extent than the coinage metals.

   (b) Unlike the coinage metals, iron reacts with acid and readily forms compounds with oxygen. It is also less malleable and has only good electrical conductivity.

4. Yes, the properties of iron are much more similar to aluminum than they are to the coinage metals. Unlike the coinage metals, both react with acid and release hydrogen gas. Both readily form compounds with oxygen. They have similar malleabilities and conductivities.

7. Alkali metal atoms have an unpaired electron. Electrons do not "like" to be unpaired, so these metals tend to get rid of these unpaired electrons by forming compounds.

8. Magnesium metal burns easily. Iron in the form of steel wool also burns easily because the iron is in thin threads. This creates a large surface area for contact with oxygen.

9. **a.** Answers will vary. An example is the following.

   The element of copper will be produced. Copper is below aluminum in the "Activity Series of Metals" table on page 122 of the textbook.

   b. Copper and aluminum (II) sulfate are the products.

10. **a.** A noble gas is chemically stable or inert.
    b. All of their electrons are paired.

11. He showed that noble gases were not completely inert.

12. Like alkali metals, halogen atoms each have an unpaired electron.

13. They are made up of different colours, and they occur in different states at room temperature.

14. **Textbook questions 2 and 3 of "Topic 4 Review," page 125:**

    2. Refer to "Appendix B" on pages 440 and 441 of the textbook. Each group on the periodic table is colour keyed. Answers will vary.

    3. Properties include the following:

    - state at room temperature
    - lustre
    - heat and electrical conductivity
    - malleability
    - ductility

Section 2: Lesson 2

1. **a.** Mendeleev looked for patterns of similar properties.

   b. He used patterns in the ordered elements to place them into columns and also rows.

   c. Gaps in his table led Mendeleev to predict the existence of elements that had not been discovered.

2. The existence of gallium was predicted before it was discovered. It is also interesting because it melts and flows in your hand.

3. Atomic numbers are the basis of the modern periodic table.

4. The atomic mass is almost equal to the mass number.

   Note: If all the atoms of an element had the same number of neutrons, the atomic mass of the element would be equal to the mass number! The fact is, some atoms of an element may have extra or fewer neutrons. Since the atomic mass is a kind of average based on atoms found naturally on Earth, the unusual atoms slightly "throw off" the atomic mass.

   An isotope of an element has a different mass number. The different mass number is due to an unusual number of neutrons in the nucleus. Some isotopes are unstable and radioactive. See "Figure 2.36" on page 134 of the textbook to see how a radioactive form of iodine is used in medical procedures.

5. Neon has ten electrons in each of its neutral atoms.

6. **Textbook questions 2, 4, and 5 of "Topic 5 Review," page 135:**

   2. There are 18 groups or columns with similar chemical properties. The elements in the rows increase in atomic number from left to right.

   4. Answers will vary. For example, modern scientists might use the periodic table to make predictions about the properties or behaviour of the elements they are considering for a particular use. They could also use the table to identify an unknown element. They may also use the periodic table simply to get information about an element.

   5. The properties of table salt are not an average of the properties of sodium and chlorine as shown by the described properties.

   Sodium is a soft, shiny, silver-coloured alkali metal that must be stored in oil because it readily reacts with air. It is a solid at room temperature, with a melting point of 97.5°C and a boiling point of 892°C.

Chlorine is a very reactive halogen gas. The gas has a greenish-yellow colour. It has a melting point of $-101.6°C$, a boiling point of $-34.6°C$, and it's toxic.

Salt is a white, transparent, crystalline solid. It dissolves in water and is used as a seasoning in food. It has a melting point of 801°C and a boiling point of 1465°C. None of these are averages of the two elements.

7. **a.** An increase in the atomic mass leads to an increase in the density of an element. Another answer could be the higher the atomic mass, the higher the density of an element.

   b. Lithium (6.941, 0.534 g/cm^3) and beryllium (9.012, 1.85 g/cm^3) show this relationship.

Section 2: Lesson 3

1. **a.** M
   b. I
   c. I
   d. I
   e. M
   f. M
   g. I
   h. I
   i. M

2. **a.** Based on the formula Al_2O_3, the two elements in alumina are aluminum and oxygen.

   b. The ratio of atoms of aluminum to oxygen is 2 to 3 in any sample of alumina.

3. **a.** Carbon dioxide is CO_2.

   b. Carbon disulphide is CS_2.

   c. Carbon monoxide is CO.

   d. Carbon tetrachloride is CCl_4.

   e. Dinitrogen oxide is N_2O.

   f. Nitrogen triiodide is NI_3.

   g. Tetraphosphorus decaoxide is P_3O_{10}.

4. **a.** Oxygen as a diatomic molecule is $O_{2(g)}$.

   b. Nitrogen as a diatomic molecule is $N_{2(g)}$.

5. Based on the formula of $C_6H_{12}O_6$, the number of atoms in a molecule of glucose is $6+12+6=24$. (This is the sum of the subscripts.)

6. **Textbook questions 1 and 2 of "What Did You Find Out?" and question 3 of "Extend Your Skills," page 138:**

   1. Hydrogen and oxygen are both diatomic molecules.

   2. They are both molecular binary compounds.

3. The formula for ethanol is C_2H_5OH—this is a molecular compound.

   Arrangements will vary. The OH (hydroxyl ion) should be kept together. An example is the following.

```
    H   H
    |   |
H - C - C - O - H
    |   |
    H   H
```

7. An atom becomes an ion when it gains or loses an electron.

8. Dissolve the substance in water and test it for conductivity. Ionic compounds readily conduct electricity, while molecular compounds do not.

9. **a.** NaCl is sodium chloride.
   b. NaF is sodium fluoride.
   c. ZnS is zinc sulfide.
   d. CaCl is calcium chloride.

10. The name of a compound does not necessarily indicate that it is an ionic element. But if a chemical name includes a Roman numeral (in brackets), then the chemical name refers to an ionic element. Ionic names do not have prefixes in them.

11. **a.** The ion $C1^-$ has a charge of -1, the ion Fe^{2+} has a charge of $+2$, and the ion Fe^{3+} has a charge of $+3$.

    If iron and chlorine react, the ratio of iron to chlorine ions must result in a neutral charge.

    For every 1 Fe^{2+} ion, there must be 2 $C1^-$ ions. This combination yields a charge of $1(+2)+2(-1)$, which equals 0, as it should. The formula representing the combining ratio is $FeC1_2$.

    Note: The chemical name for $FeC1_2$ is iron (II) chloride.

    There is another ionic compound that could form. This is the compound involving the Fe^{3+} ion. For every 1 Fe^{3+} ion, there must be 3 $C1^-$ ions. This combination ratio yields a charge of $1(+3)+3(-1)$, which equals 0, as it must. The formula representing this ratio is $FeC1_3$.

    Note the chemical name for $FeC1_3$ is iron (III) chloride. **Reminder:** The Roman numeral represents the ion's charge, not the number of ions.

b. The definite fixed ratios of elements for these two iron compounds are as follows. In iron (II), chloride involves 1 iron atom to 2 chloride atoms. The combining ratio for iron (III) chloride is 1 iron atom to 3 chloride atoms.

12. Textbook questions 1 to 3 from "What Did You Find Out?" on page 141:

1. **(a)** Eighteen sodium ions are represented.
(b) There are 18 chloride ions represented.

2. This portion of a salt crystal does contain 18 ions of both sodium and chlorine. However, chemical formulas of ionic compounds are standardized as simple ratios. So, the formula for table salt could be written as Na_1C1_1 (ratio = 1:1). **Note:** The presence of the chemical symbol alone indicates that an atom of the element is present so the redundant "1" is dropped from the notation.

3. Like ions, the opposites attract and similar charges or poles repel.

13. Textbook questions 1 to 5(a) from "Analyze" and "Conclude and Apply," page 143:

1. **(a)** Sodium iodide, copper (II) nitrate, and magnesium chloride are all ionic.

(b) Generally, a metal (left side of the periodic table) and a non-metal (right side of the periodic table) combine.

2. **(a)** Paraffin wax, sucrose, and starch are molecular compounds.

(b) Molecular compounds are made from non-metals—they are noted on the right side of the periodic table. They are sometimes combined with hydrogen.

3. **(a)** Yes, ionic compounds generally seem to be soluble in water.
(b) No, molecular compounds generally seem to be insoluble in water.
(c) Yes, sucrose is a molecular compound that is soluble in water.

4. Ionic compounds seem to be harder.

5. **(a)** Ionic compounds seem to have the higher melting point.

14. Graphite is an elemental molecule. Only carbon is involved.

15. **Textbook questions 1, 2, 3, 6, and 7 of "Topic 6 Review," page 144:**

  1. Properties of molecular compounds generally include the following:

     - low or no solubility in water
     - non-conducting/don't form ions in solution
     - some have odour
     - a low melting point
     - form from non-metallic elements

  2. Properties of ionic compounds generally include the following traits:

     - soluble in water
     - conduct electricity/form ions in solution
     - have no odour
     - have a high melting point
     - form from metallic and non-metallic elements
     - are solid at room temperature

  3. Transferring electrons to other atoms creates an ionic compound. Sharing electrons with other atoms creates a molecular compound.

  6. Lithium chloride (LiCl), zinc sulfide (ZnS), and sodium fluoride (NaF) are all ionic compounds. Molecular compounds in this list are sulfur dioxide (SO_2), carbon monoxide (CO), and hydrogen chloride (HCl).

  7. Hydrogen peroxide has two atoms of hydrogen and two atoms of oxygen for a total of four atoms.

16. **a.** I
  b. I
  c. I
  d. I
  e. I
  f. M
  g. M
  h. M
  i. M

Section 2: Lesson 4

Check all the answers in this lesson with your teacher or home instructor.

Section 3: Lesson 1

1. In a chemical reaction, *reactants* react to produce *products*.

2. Common reactions include the following:

    - sodium bicarbonate (also called sodium hydrogen carbonate or baking soda) from pancreas neutralizes stomach acid
    - hemoglobin production
    - hydrochloric acid produced in the stomach's gastric glands
    - calcium phosphate produced to build bones
    - burning charcoal
    - drying paint

3. **Textbook questions 1 to 4 of "What Did You Find Out?" on page 147:**

    Note that answers will vary, according to the stations that are used. Sample answers will be given for stations I, II, III, IV, and V as described in the Student Module Booklet.

    1. Stations I and IV had chemical reactions. Light and heat were produced in station I, and wax was used up.

        In station IV the commercial antacid tablet was used up as gas bubbles escaped—carbon dioxide was produced.

    2. There were physical reactions in station II—the frozen, flavoured water simply changed state as it melted. This is a physical reaction or change.

        The sugar simply dissolved in station III for a physical reaction. It would be possible to recover the sugar by evaporating off the water.

        In station V the boiling water simply changed state. This is a physical reaction. Water can be recovered by letting the escaping water vapour condense on a cool object.

    3. The inferences may vary. Carbon dioxide and soot were produced in station I, while carbon dioxide was the gas produced in station IV.

4. Answers will vary. Chemical reactions in daily life include the following:

    - Plants in the house and in the garden photosynthesize to make food.
    - Gasoline is burned in a motor vehicle to provide energy for motion.
    - When food is digested, it changes chemically to provide energy to the body.
    - When a writable CD is "burned," the laser beam changes the molecular structure of dye in the CD.
    - When biscuits are made with baking soda or baking powder, carbon dioxide gas is produced in the dough. This gas causes the biscuits to rise.

4. **Textbook questions 2 and 4 of "Topic 7 Review," page 152:**

    2. Answers may vary. Here are some examples of chemical equations in words and in symbols. **Note:** All subscripts are in brackets. You may omit all coefficients in the symbolic version of the equations.

        - silver and bromine yield silver bromide

        $$Ag_{(s)} + Br_{(l)} \rightarrow AgBr_{(s)}$$

        - magnesium and oxygen produce magnesium oxide

        $$2\,Mg_{(s)} + O_{2(g)} \rightarrow 2\,Mg_{(s)}$$

        - vinegar + baking soda → sodium acetate + water + carbon dioxide

        $$HC_2H_3O_{(aq)} + NaHCO_{3(s)} \rightarrow NaC_2H_3O_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$$

    4. The products are on the right side of the arrow. The reactants are on the left side of the arrow. Note the following:

        reactants → products

5. a. In a reaction, atoms are neither lost nor created. They just change *partners*.
    b. Forces that cause a group of atoms to act as a unit are called *chemical bonds*.
    c. Chemical bonds store *energy*.
    d. Energy is *absorbed* when bonds break and *released* when bonds form.
    e. All chemical reactions involve *energy* changes.
    f. *Exothermic* reactions release heat, light, sound, chemical, or electrical energy.
    g. *Endothermic* reactions absorb energy.
    h. The definite fixed ratio for nitroglycerin would be *3 carbon : 5 hydrogen : 3 nitrogen : 9 oxygen*.

6. Textbook questions 1 and 3 of "Topic 7 Review," page 152:

1. A chemical reaction has occurred when

- energy is absorbed (endothermic) or released (exothermic), and there's no apparent physical source such as a heat source
- the reaction is irreversible or must be reversed with another chemical reaction
- bubbles in a liquid medium may indicate that a gas is being formed—there's no apparent physical source such as carbonation
- a precipitate has formed in a liquid medium
- there's a change in colour or odour
- there's an increase or decrease in mass when the reaction is open to the atmosphere, and there's no apparent physical source such as evaporation

3. Answers will vary. Note the examples.

Endothermic reactions absorb energy and include frying an egg and the electrolysis of water.

Exothermic reactions release energy. Examples include combustion and cellular respiration.

Section 3: Lesson 2

1. Ways to increase the reaction rate include the following:

- Cut, break, or grind the reactant(s) into smaller pieces. This increases the chemical contact surface area (the surfaces where the reactants touch). More contact between the reactants creates a faster reaction rate.
- Dissolve the reactant(s) in a solvent. This increases contact between reactants by breaking them up into molecules or ions, giving them much greater mobility, and distributing them through a greater area.
- Increase the temperature to make the particles more active.
- Increase the concentration. If there are more particles to react, the reaction will occur more quickly.
- Stir or agitate the reactants. This mixes the reactants so that unreacted particles can get together more quickly.
- Use a catalyst. Catalysts help the reactants get together.

2. **Textbook questions in steps 1 and 2 of "Procedure," page 154:**

   Step 1: Chemical reaction A would be faster because the calcite is in smaller pieces. And B would be faster because the concentration is higher.

   Step 2: Reaction C would be slower because it's not stirred. The reaction in D would also be slower because the temperature is lower.

3. **Textbook questions 1 to 3 of "What Did You Find Out?" on page 154:**

   1. Additional changes could be a higher temperature or concentration, and stirring.

   2. You could slow down the chemical reaction by having a lower temperature or concentration.

   3. Aqueous sodium hydroxide reacts with aqueous hydrochloric acid to produce aqueous sodium chloride and liquid water.

4. The inhibitor slows down the rate at which hydrogen peroxide naturally breaks down into water and oxygen. **Note:** Storing hydrogen peroxide in a dark bottle and in a cool, dark place, also decreases the decomposition rate. This reduces the amount of light and heat energy the hydrogen peroxide can absorb.

5. Meat tenderizers and contact lens cleaning solutions contain enzymes called *protease* to break down proteins.

6. Corrosion can be decreased in these ways:

   - galvanizing
   - electroplating
   - painting
   - plasticizing
   - oiling the surface to prevent oxygen and water from reaching it
   - washing off salts and acids
   - keeping the object cool and dry

7. **Textbook questions 1, 3, and 5 of "What Did You Find Out?" on page 158:**

   1. Initially, the water level was probably slightly below the level of the water outside the bottle. The water should have risen to about one-fifth the height of the bottle in the two-week period.

   3. A chemical reaction took place because rust was formed. The rust is a new substance.

   5. Oxygen is needed. One-fifth of the volume of air is oxygen. The water rose one-fifth of the way up. This corresponds to oxygen being used up.

8. Textbook questions 1 to 4 of "Analyze" and question 5 of "Conclude and Apply," page 161:

1. Carbon dioxide, water, and carbon in the form of soot are products. Carbon dioxide extinguished the match in part 3. Water condensed from the gases in part 2. Soot may have formed on the foil in part 3.

2. Heat and light, which are produced, are most important. Light is needed at night and heat is needed to keep homes warm.

3. Oxygen from the air is used up by the flame. This is indicated by the rise in the water level.

4. Answers will vary. The following are safety precautions:

   - Tie loose hair back.
   - Wear safety goggles.
   - Use matches with care.
   - Check that there are no flammable substances nearby.

   Awareness of safety during investigations would be improved through the following:

   - Pay attention to WHMIS and any other safety symbols on substances involved in the investigation.

   - Pay attention to the safety icons in the Student Module Booklet and in the textbook.

   - Listen to any instructions from your home instructor or teacher about precautions to take.

   - Take note of sharp objects, flammable materials, and volatile poisons.

   - Find the location of any high voltage sources of electricity.

5. The black substance is C, and it's the element called carbon. Candle wax is a compound containing hydrogen and carbon which are chemically combined. Carbon is a product of the incomplete combustion of wax.

9. Oxygen is always a reactant. Carbon dioxide and water are always produced.

10. The reaction occurring in the flask in "Figure 2.59" of the textbook is a combustion reaction. **Note:** The iron is burning to form iron oxide—rust. This is exactly the same reaction as the corrosion reaction. It is just happening a lot faster. The corrosion reaction also releases heat. However, because rusting is such a slow reaction, the heat has lots of time to disperse into the environment and you cannot detect it.

11. Carbon particulates (soot, smoke) and carbon monoxide result from incomplete combustion.

12. **Textbook questions 3, 4, and 8 of "Topic 8 Review," page 164:**

3. **(a)** Reactants react to produce products.

   (b) While neither changes in a reaction, a catalyst speeds up reaction rates and an inhibitor slows them down.

   (c) A chemical reaction involves breaking chemical bonds between atoms (reactants), rearranging the atoms, and creating new chemical bonds (products). The reaction rate is the speed at which these changes occur.

4. **(a)** Concentration: An increase in the concentration of any reactant increases the rate of a chemical reaction.

   (b) Surface area: An increase in the surface area of any reactant increases the rate of a chemical reaction.

   (c) Temperature: An increase in the temperature of any reactant increases the rate of a chemical reaction.

8. Burning fuel provides us with, among other things, energy to run vehicles, cook food, generate electricity, and manufacture products.

   However, combustion always releases the greenhouse gas known as carbon dioxide. Burning fossil fuels releases acid rain precursors (sulfur and nitrogen oxides) and a variety of other toxins. Burning wood and fossil fuels releases carbon particulates and carbon monoxide, while burning plastics release a variety of toxic gases.

13. Forensic technicians use chemistry to develop fingerprints. They also use chemistry to locate and identify bodily fluids.

Section 3: Lesson 3

Check all the answers in this lesson with your teacher or home instructor.

Module Review

Check all the answers in this review with your teacher or home instructor.

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